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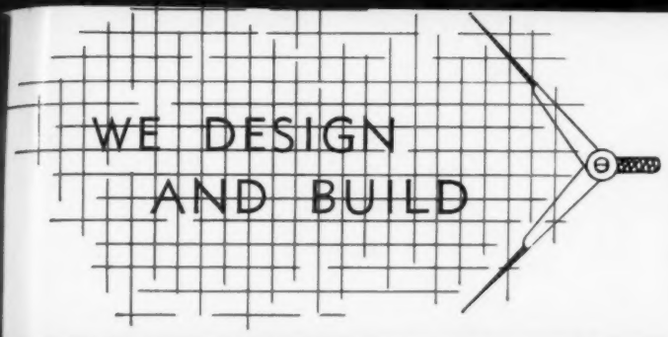

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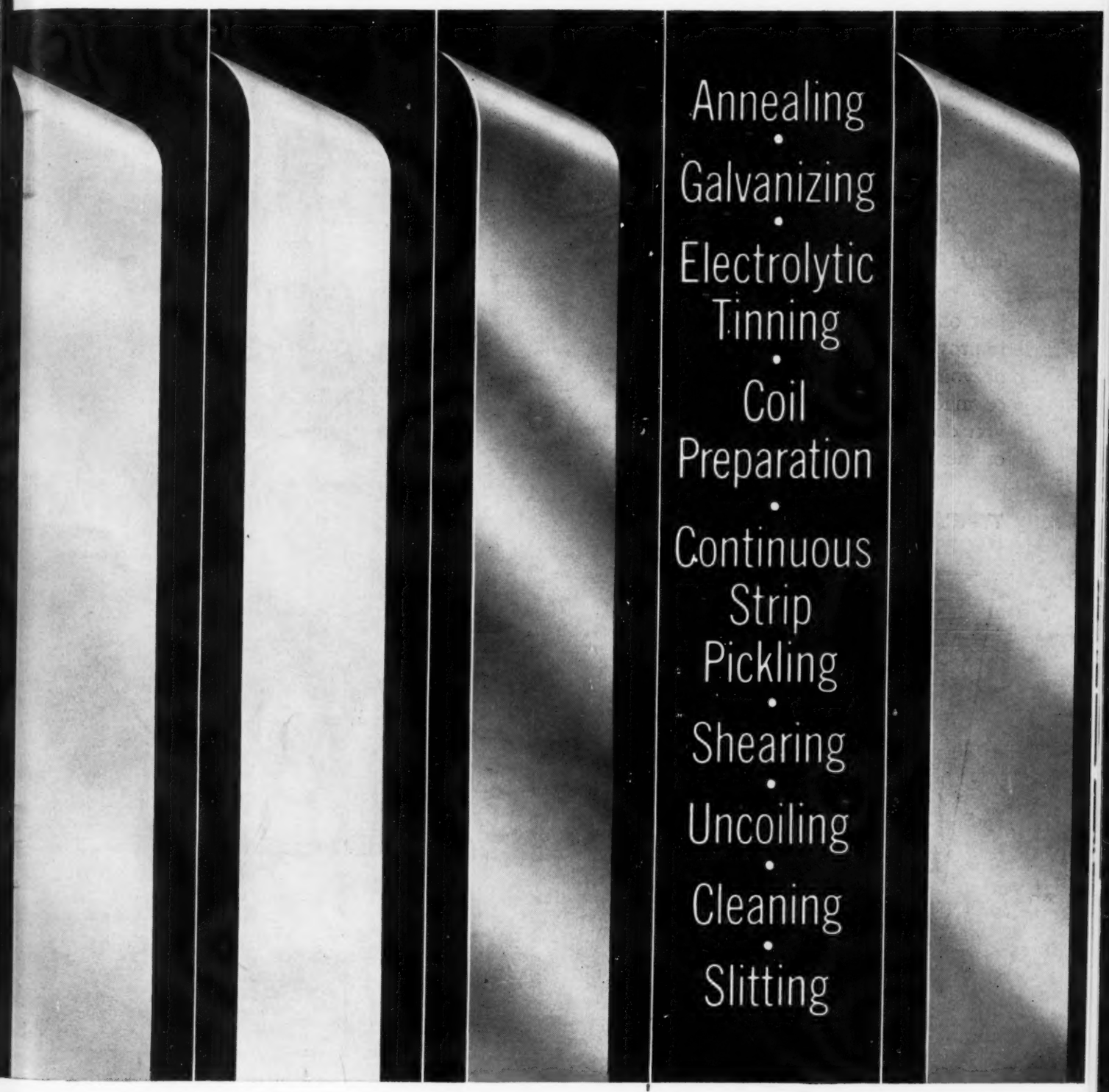

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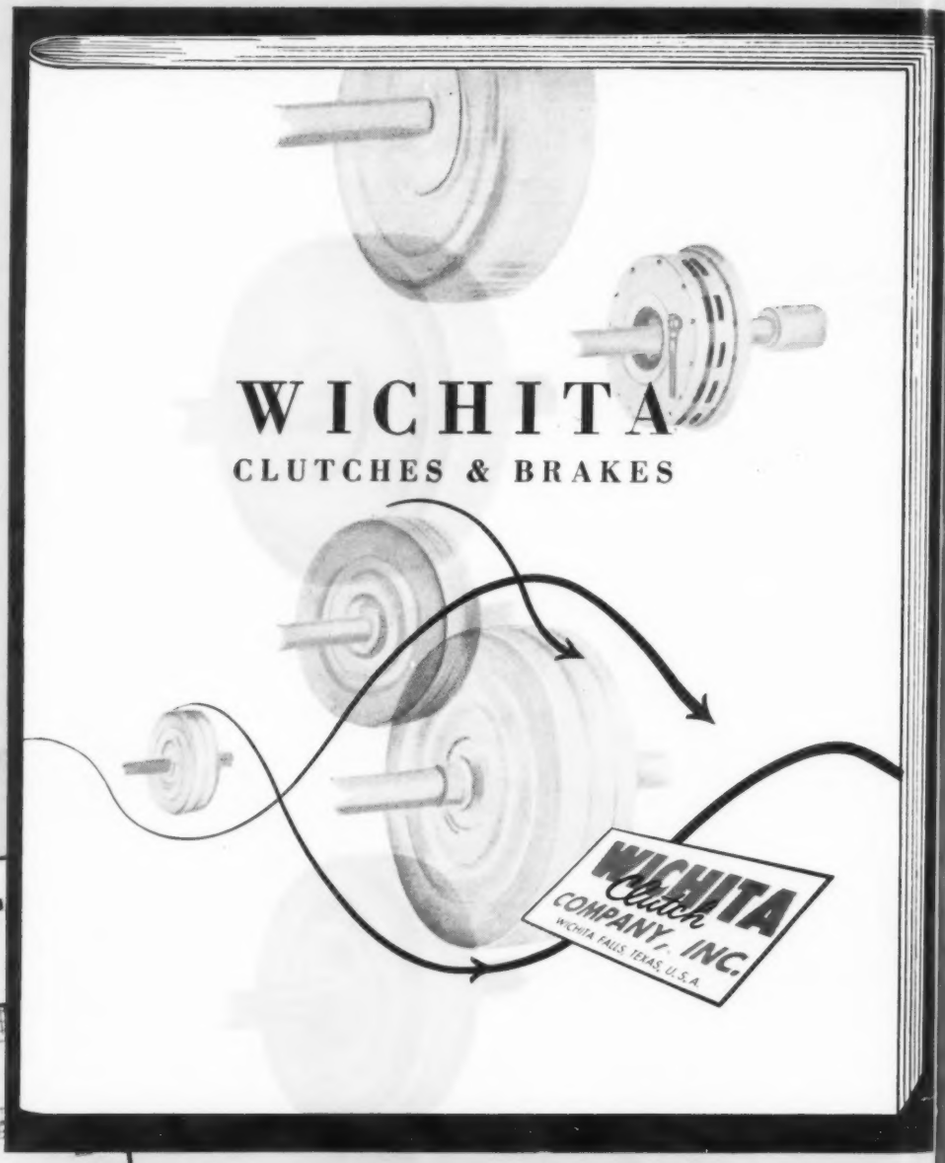

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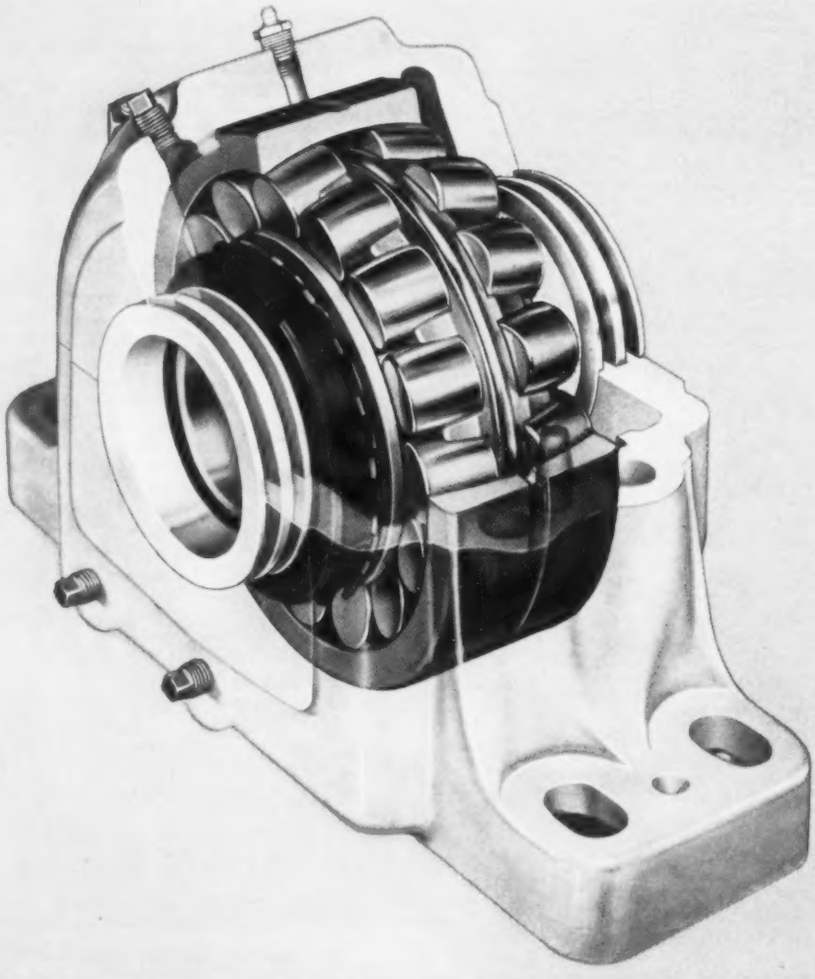

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Six Automatic Gauge Control installations have now been completed or ordered in North America and Licensees in North America for the Davy-United system of Automatic Gauge Control include General Electric Company of the U.S.A., Canadian General Electric Company Limited and Canadian Westinghouse Limited.

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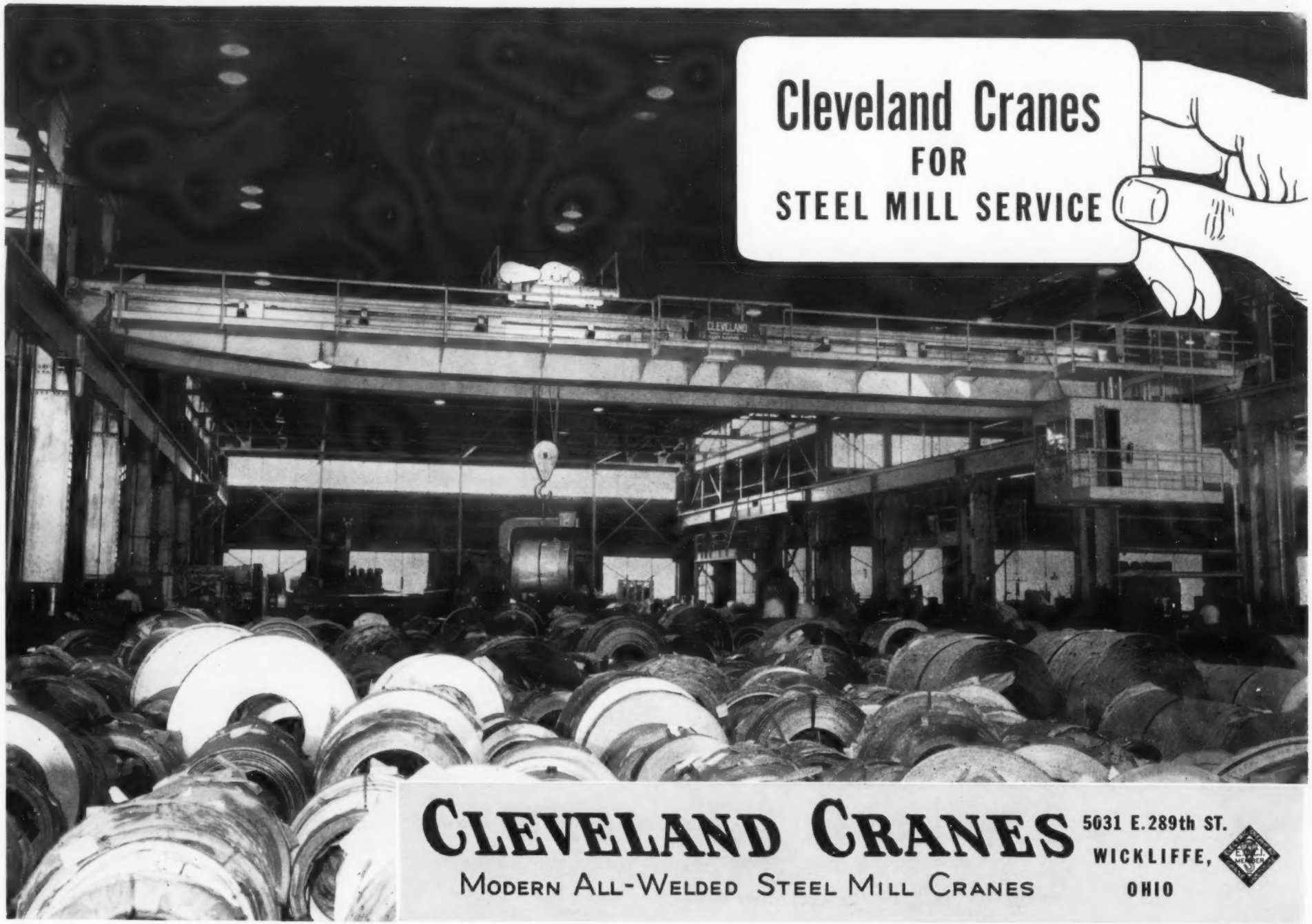
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Crops *and* Shorts

△ Reminiscent of an old wise-crack, there is just as much steel being made, only different people are doing it. World steel production for the first half of 1961 is reported as 182,000,000 tons. Actually, this is down 4 per cent from the first half of 1960, but only because the United States production dropped 26 per cent. Excluding the U. S., world production rose 7 per cent. In round figures, production was 44,900,000 tons in the United States, 38,400,000 tons in the Soviet Union, 19,000,000 tons in West Germany, 14,600,000 tons in Japan, 13,700,000 tons in Britain. The effect of the Japanese expansion is evident in their rise to fourth place in world steel production.

△ There is food for thought in the announcement that American Can and Continental Can have bought 11,000 tons of tin plate from Steel Company of Wales. And more food for thought in recent quotations on galvanized wire: $113 per ton in Europe, $123 in Japan and $195 in the United States. Still more: cold rolled sheets in Europe $105 per ton as against $155 a year ago. Present U. S. price, $126. But Dave McDonald thinks the import problem in steel is "relatively inconsequential."

△ Speaking before the House subcommittee on the impact of imports and exports on American employment, R. Conrad Cooper, U. S. Steel's executive vice president—personnel services, emphasized the change of the United States from a steel exporter to a steel importer. From 1950 through 1957 the United States had a foreign trade balance in steel mill products averaging about 2,400,000 tons per year. In 1960 there was a deficit of more than 350,000 tons. In 1960, import percentages of the domestic supply of various products reached 24 per cent of reinforcing bar, 7 per cent of pipe and tubing, 18 per cent of wire and wire products (31 per cent for wire rods, 43 per cent for nails and staples and 53 per cent for barbed wire).

Mr. Cooper said, "Prominent among the reasons for these trends are the persistence of our competitive hourly employment cost disadvantage and the narrowing of our competitive advantage in productive efficiency."

Before the same committee, H. S. Potter, vice president of sales for Carpenter Steel Company, compared an estimate of 12,000 tons of tool steel imported in 1960, about 12 per cent of domestic production, with 1958 figures of 2900 tons, about 4 per cent of production. He cited import prices as much as 55 per cent below some current prices.

△ The Russians brag about the missile gap but are strangely quiet about their superiority in solving the problem of how not to produce too much food.

△ The use of oxygen in the steel industry has grown tremendously, increasing by 68 per cent in the past two years. Consumption in 1960 was 48,263,000,000 cu ft, or 486 cu ft per ingot ton. Of this, 29,213,000,000 cu ft, or 294 cu ft per ingot ton, went to steelmaking. This item will grow as more basic oxygen units are completed and as the demand for steel increases.

△ A few optimists are predicting that U. S. steel production between mid-1961 and mid-1962 will equal the record 117,036,085 tons produced in 1955.

△ Twenty years ago the steel industry of the United States represented an investment of $4,250,000,000, about equal to annual sales. Now the investment is $13,500,000,000 and annual sales about the same: It is still a once-a-year turnover—perhaps a little better in boom times. One important difference: the 1940 investment worked out to $52 per ton of annual capacity. The present figure is $91.

△ A student of human nature says that the old list of certainties—death and taxes—must be expanded: no woman is wearing shoes too large for her.

△ A six-year evaluation program by Dow Chemical Co. indicates that corrosion protection in industrial-marine atmospheres is improved by 20 to 90 per cent when slight amounts of magnesium (0.04 to 0.05 per cent by weight) is present in the hot-dip galvanizing bath.

△ Figures released by the American Iron and Steel Institute for the first half of 1961 put the industry's total employment at 501,000 hourly and salaried workers, with an aggregate payroll of $1,778,788,586. Wage earners worked 36.4 hours per week. The payroll cost per hour worked by hourly employees was $3.468, while the total employment cost, including fringe benefits, was over $3.93.

△ From the voice of experience:
They call it legal tender,
  That green and lovely stuff.
It's tender when you have it
  But when you don't, it's tough.

△ Judging from performance to date, F. W. Dodge Corp. believes construction contracts to be headed for their 15th consecutive record-breaking year in 1961. Total construction contracts in the first half rose to $18,200,000,000, a gain of 4 per cent over the comparable period last year.

△ Beginning salaries for graduating engineers are 4 per cent higher this year than last, according to Cornell University. Salaries ranged from $444 to $833 a month, with a median of $566. The report also pointed out that exceptional experienced engineers are now being better paid without being moved into administrative work.

△ October 22–28 has been designated Cleaner Air Week, sponsored by the Air Pollution Control Association.

△ A sign of the times: eat, drink and be merry, because tomorrow you might lose your credit cards.

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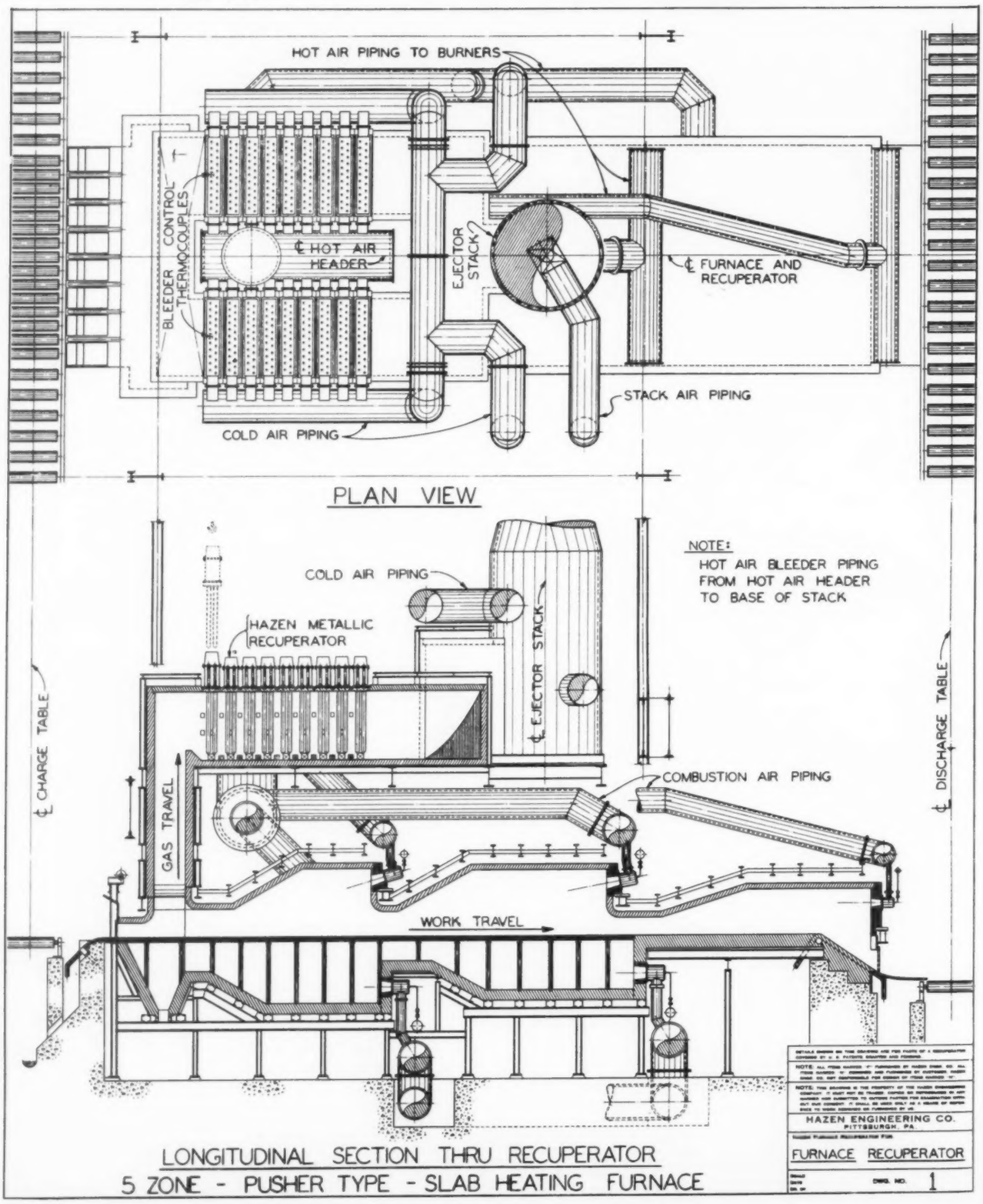

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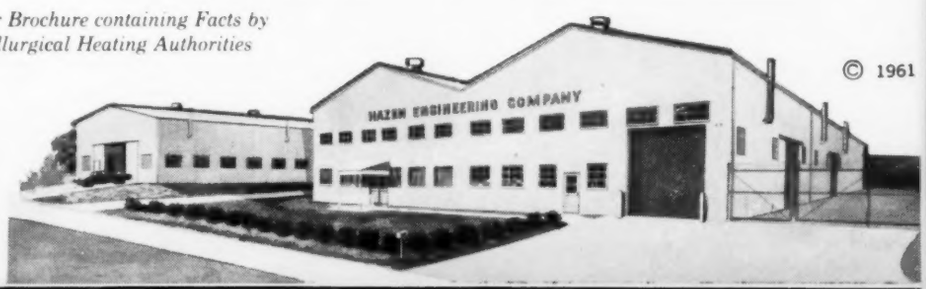

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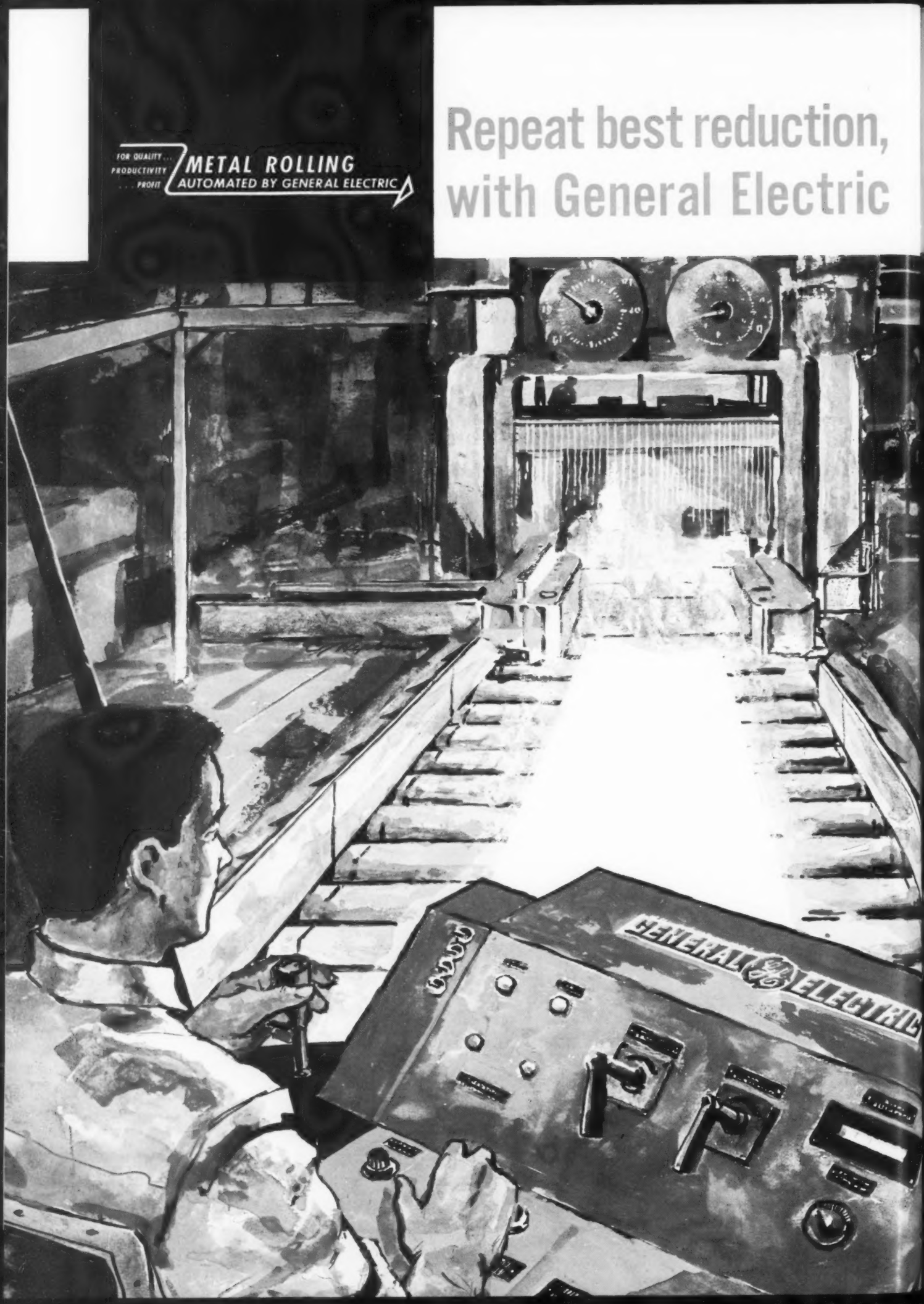
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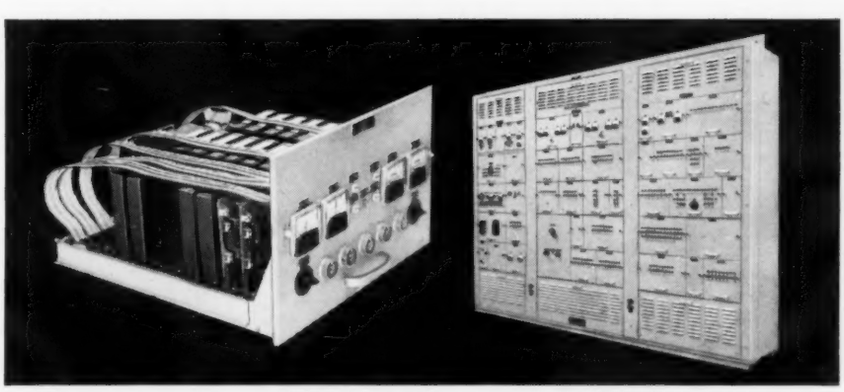

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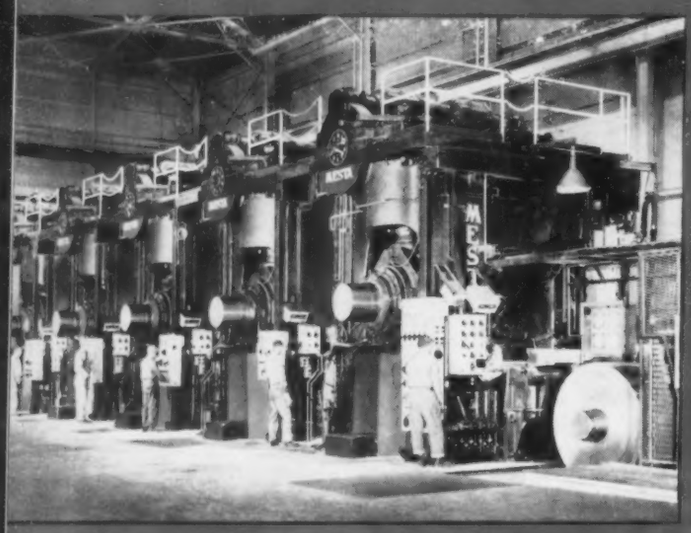
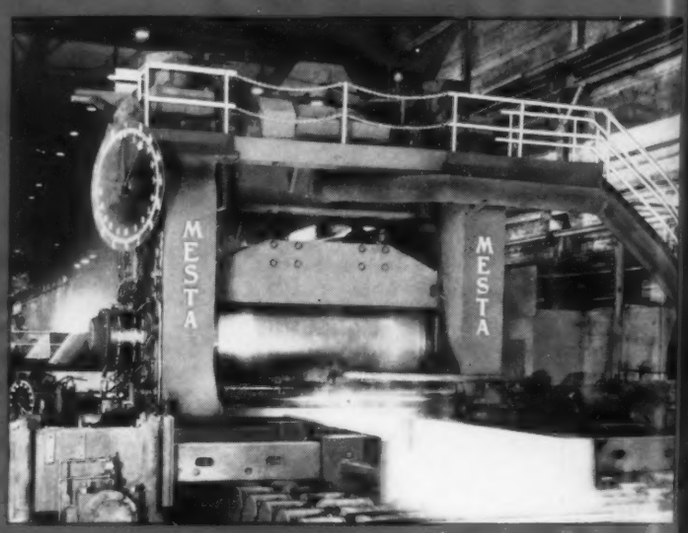
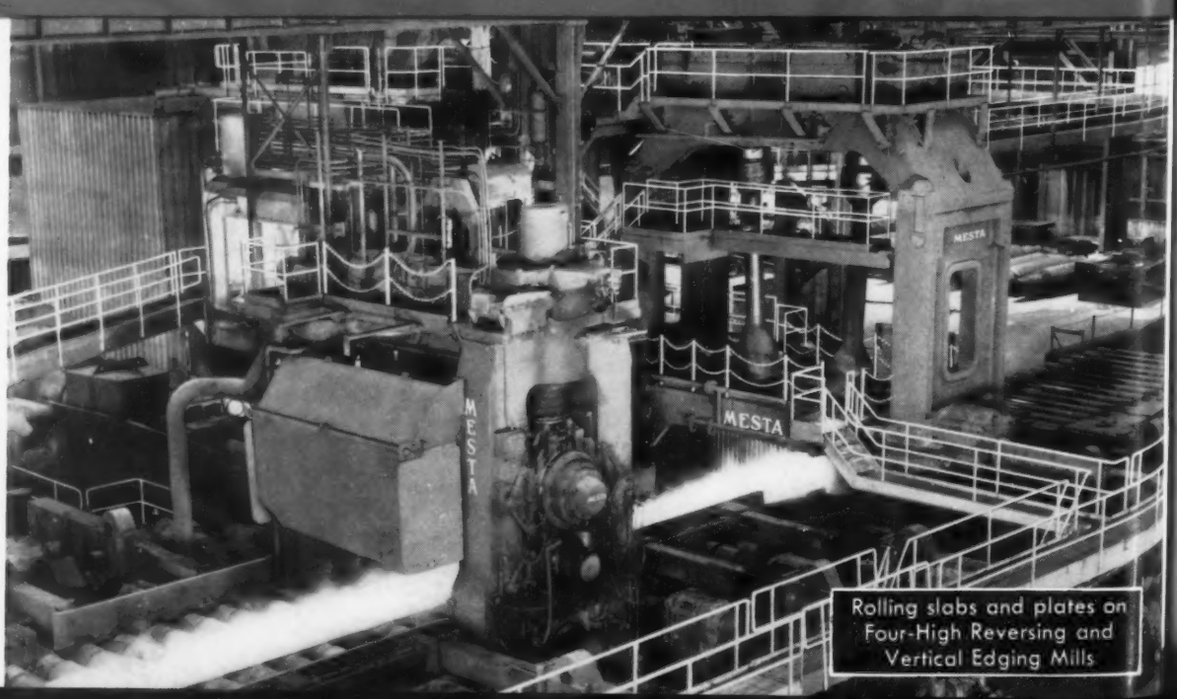


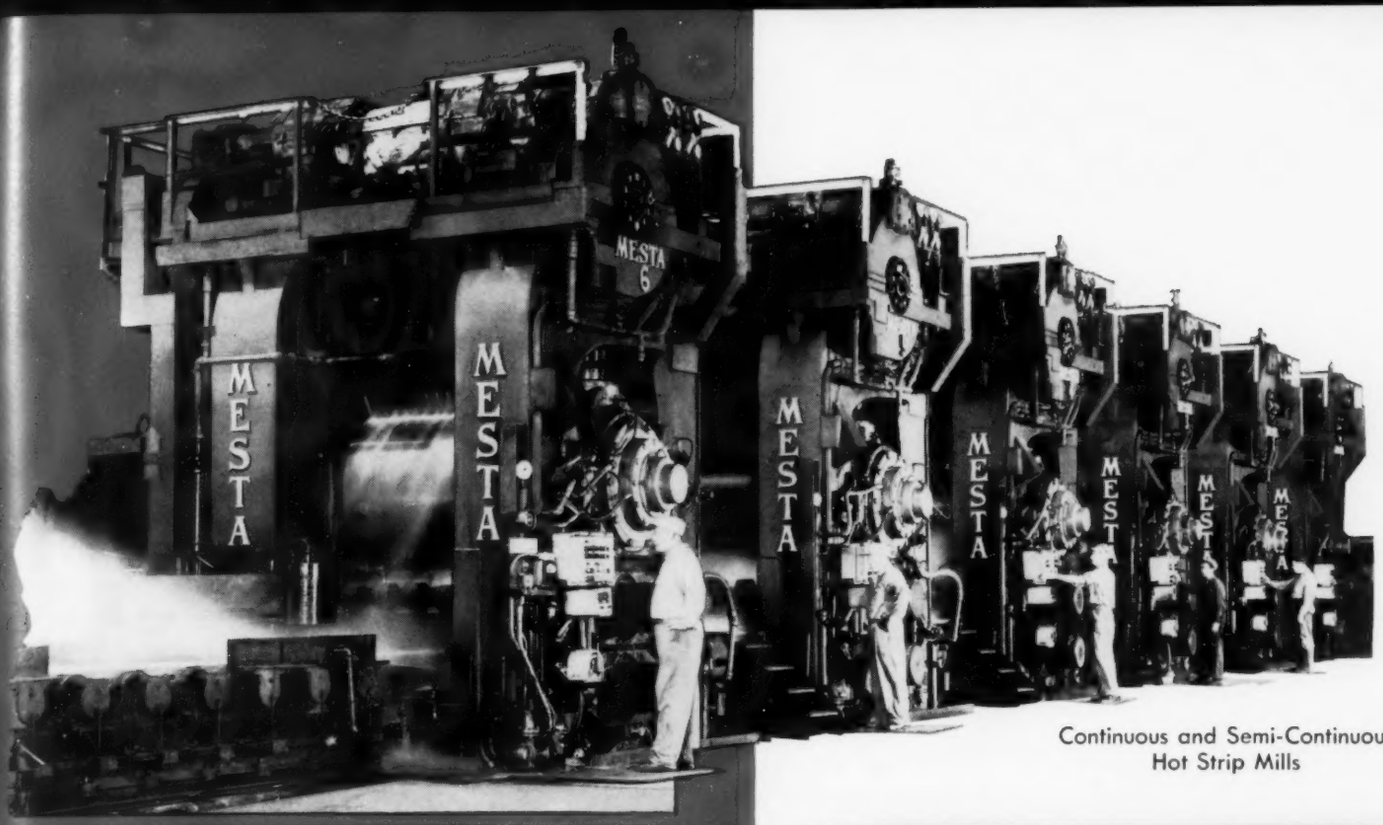
Four-High High-Speed Tandem Cold Mills



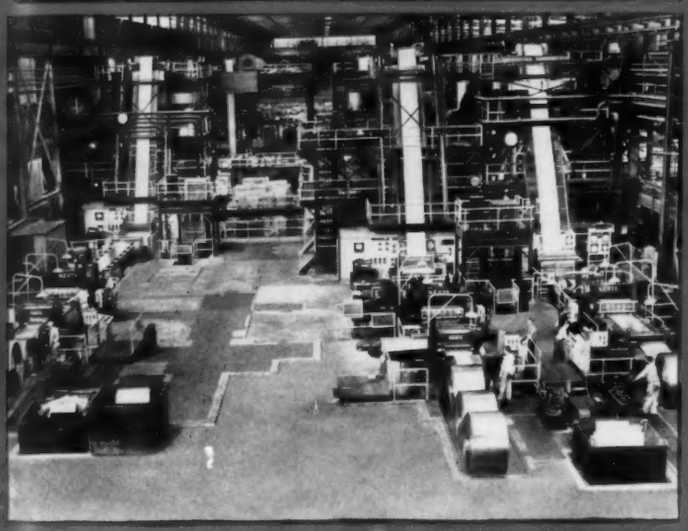
Four-High Reversing Plate Mills



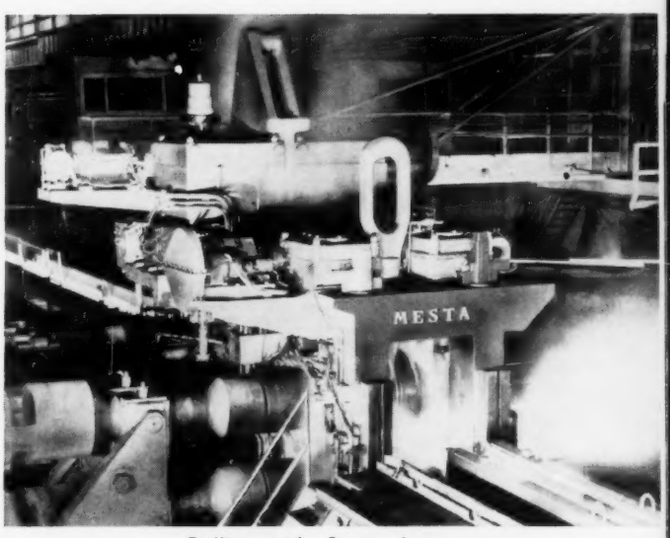
Rolling slabs and plates on Four-High Reversing and Vertical Edging Mills



Continuous and Semi-Continuous
Hot Strip Mills



Continuous Galvanizing Lines



Rolling wide flange beams on
MESTA Universal Structural Mills

MESTA MACHINE COMPANY

PITTSBURGH,

PENNSYLVANIA

Two-High Reversing
Slabbing-Blooming Mills

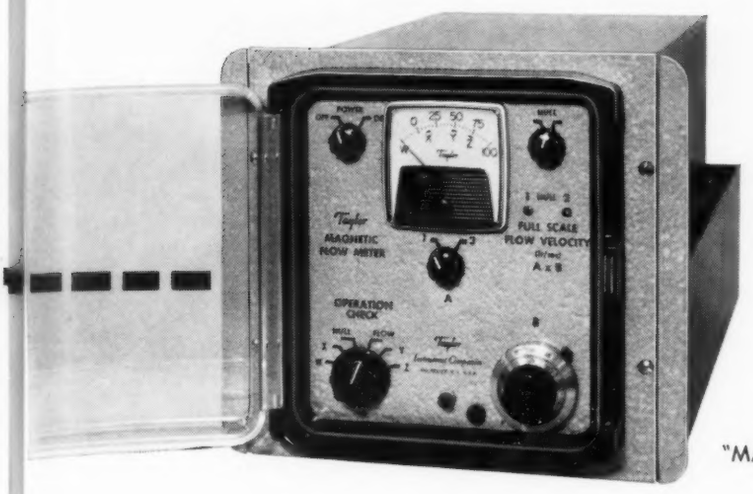
712NE
"MAG-PIPE" Sensing Head

Taylor presents a **MAGNETIC F**

OUTSTANDING FEATURES

- High accuracy—½% of full scale on most ranges.
- Full scale velocities as low as ½ ft./sec., at only slightly reduced accuracy.
- Conductivity range—as low as distilled water.
- Rangeability—½ to 30 ft./sec. full scale calibration, continuous vernier adjustment.
- Amplifier—solid state.
- Ideally suited for long transmission runs to a central control panel.
- Output signal—1-5 ma DC into any load from 0-3000 ohms. (Electro-Pneumatic Transducer or TRANSCOPE Electronic Control System).

Taylor Instruments **M**



717TE
"MAG-PIPE" Transmitter

FLOWMETER TRANSMITTER WITH 1/2% ACCURACY

The new Taylor "MAG-PIPE" Magnetic Flowmeter Transmitter is a high quality, high performance transmitter with an output signal of 1-5 ma suitable for transmission over long distances. It can therefore be used with miniature receivers and controllers in central control rooms.

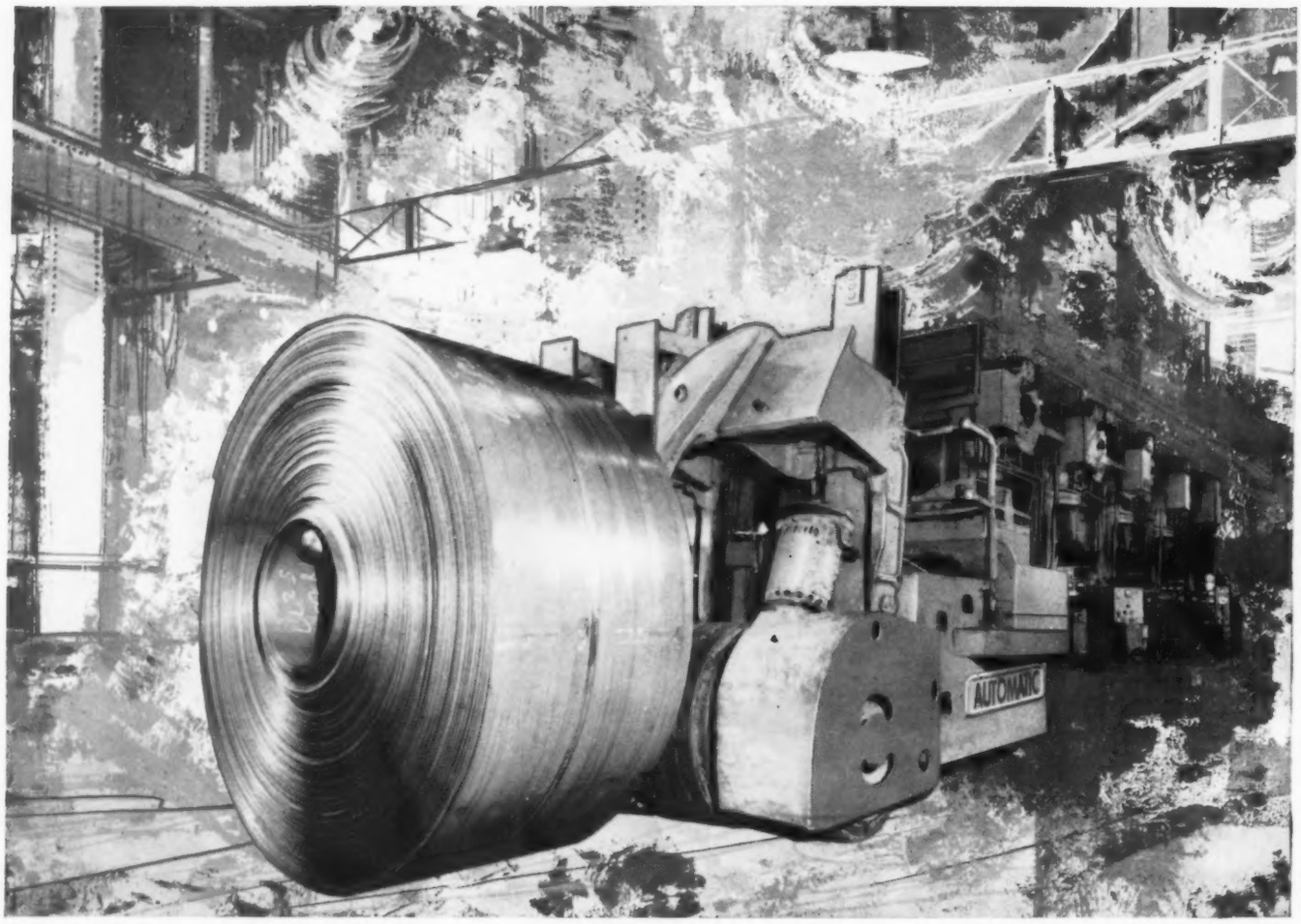
It is designed to measure flow of fluids with an electrical conductivity as low as that of distilled water. It is ideally suited for very low flows, viscous liquids and liquids containing suspended solids, since the flow is not in any way restricted by the primary element.

The "MAG-PIPE" sensing head is mounted in the flow line. It comprises a flow tube, an AC magnetic circuit and two electrodes. The sensing head housing is "hose-down proof" (explosion-proofing optional), and has Van Stone type flanges for easier, faster installation.

The transmitter employs *solid state* components, being fully transistorized for long-term reliability. It is standard in fixed-range form, in which case calibration is factory set at the desired range. Optionally available with a full-scale vernier adjustment on two ranges. A built-in output meter doubles as a circuit checking device.

The "MAG-PIPE" Flowmeter Transmitter is in production. Consult with us on your difficult flow measurement problems. See your Taylor Field Engineer or write for **Bulletin 98418.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.

MEAN ACCURACY FIRST



One turn: Over 1100 tons of tin plate

Kerns "Kleen-Strip"® rolling oil helps pace record turn tonnage

A major mill recently rolled over 1100 tons of tin plate in a single turn utilizing a Kerns "Kleen Strip" rolling oil. Its monthly average turn tonnage record is over 800 tons a turn. One of the reasons tonnage runs consistently high: the rolling oil, formulated and personalized by Kerns United, meets the specific operational requirements of the mill. A good reason why so many mills have turned to Kerns.

This is what a personalized *"Kleen Strip" rolling oil can mean to your mill operation . . .*

Easier reductions • Cleaner strip off the mill and through the anneal • Greater prime yield • Increased tonnage, with faster mill speeds • Faster start up after solution change or downtime • Lower mill loads • Lower cost per ton.

Kerns "Kleen Strip"* rolling oils are formulated to meet specific mill requirements, have consistent quality and uniformity from shipment to shipment. They are extremely stable, and when stored over long periods will not deteriorate. And from Kerns you get a complete product, no additives are required. Ask your Kerns representative to call, or write for details.

PERSONALIZED LUBRICANTS FOR INDUSTRY

KERNS UNITED Corporation

824 State Street · Calumet City, Illinois

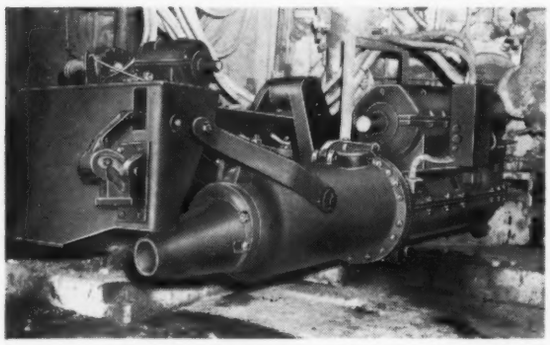
Subsidiary: Kerns Pacific Corporation, 630 N. Batavia St., Orange, California

*Patents pending

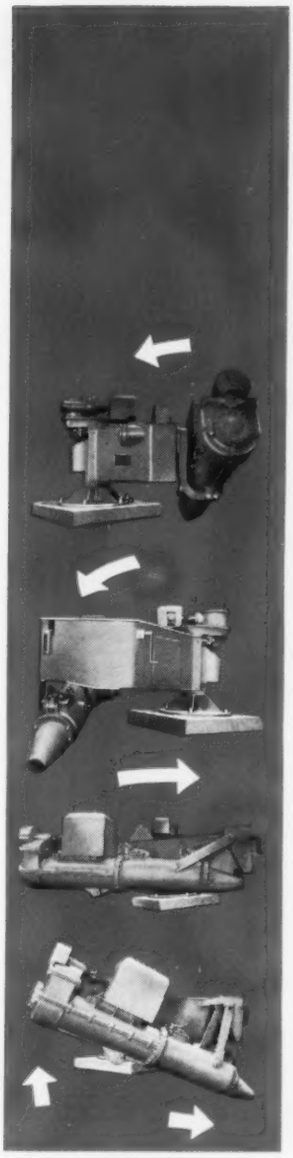
ACCURACY+POWER

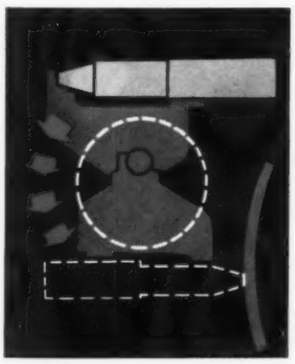
FOR MAINTAINING LONG TAPPING HOLES

BAILEY CLAY GUNS



Precisely accurate due to unique mounting and 3-motor operation, Bailey Clay Guns furnish the high clay pressures (642 to 1150 psi) which are so necessary with the new coke-tar tapping hole mixes now being used on many furnaces. Designed for safety and reliability in blast furnace and large electric furnace applications, there are more than 170 in service. *Write for Bulletin.*





Clear of the tapping hole when not in use, Gun swings to the correct position for moving into the tapping hole.

WILLIAM M. **BAILEY** COMPANY · 1221 BANKSVILLE ROAD, PITTSBURGH 16, PA.

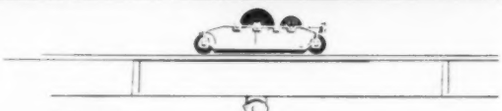
WORLD'S LARGEST LADLE CRANE

. . . designed and built by Morgan

This 650-ton giant has stepped up steel-making efficiency for a major steel producer in Hamilton, Ontario, Canada.

The 19-foot wide ladle holds 500 tons of hot metal—total volume is three times that of an average 5-room house. Morgan engineers specified special low-alloy, high-strength steel for main and auxiliary girders. Crane wheels can be changed by jacking up the trolley or bridge just a fraction of an inch—adding to speed and efficiency. A 5-deck cage houses electrical controls and the operator.

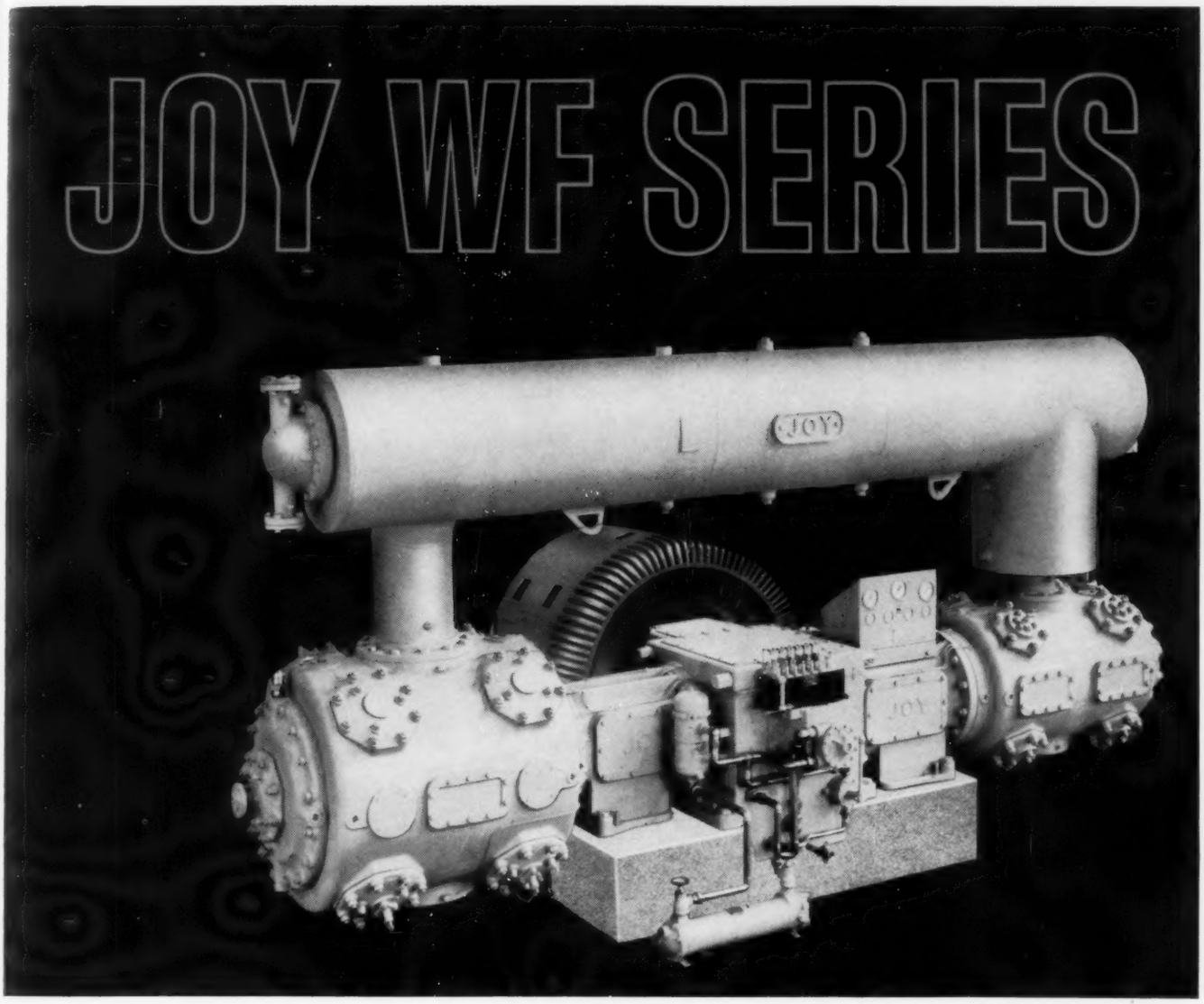
For any steel-handling operation requiring absolute precision in design and manufacture, Morgan cranes and mill machinery provide the ultimate in profitable, trouble-free performance. Let our representative show you how to speed production and lower costs in your mill.



THE **MORGAN** ENGINEERING CO. *Alliance, Ohio*

Overhead electric traveling cranes, gantry cranes,
open hearth special cranes, blooming mills, structural mills,
shears, saws, auxiliary equipment and welded fabrications.

JOY WF SERIES



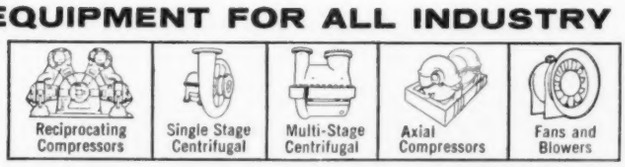
Announcing A Series of Horizontal Opposed Compressors in the 300-2000 HP Range

Designed for the great bulk of industrial air and gas applications, the WF series is the result of Joy's experience with over two and one half million compressor horsepower in the field. Every component is designed for dependability and ease of maintenance.

Installation and maintenance costs of the WF series are held to a minimum due to superior design. Since the motor rotor is mounted directly on the compressor shaft, alignment problems are minimized, installation is simplified, and less floor space is necessary.

The WF-102 air compressor pictured above has a displacement of 1972 CFM, and is driven by a 300 HP motor when discharging at pressures up to 125 PSIG. Larger models of Joy horizontal opposed compressors are also available as well as vertical, V-vertical, and turbodynamic machines. For additional information on the WF series write for Bulletin 3369-68.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Below: **A row of Elliott C-W mill motors driving bullet rolls at the delivery end of a billet mill.**

"All of these motors are descendents of America's 1st mill-type motor."

From research to reel drives . . .

Elliott C-W Mill Motors serve the

All along the production lines of America's steel mills, you will find Elliott C-W mill motors driving screwdowns, edgers, run-out tables, shears and coilers. And back of these, Elliott motors furnish power for unloaders, cranes, hoists and other important equipment that moves ore from ships to furnaces.

All this began back in 1904 when Crocker-Wheeler introduced the nation's first mill-type motor. Today, nearly three-score years later, Elliott's newest mill-type motors—the ruggedly-built 620, 622 and 624 frames—incorporate the latest developments in sound, fundamental design. They feature rolled steel frames, split horizontally for easy access . . . glass-bonded Type H insulation . . . low armature inertia for fast speed reversals and reduced operating costs . . . and easy-access, spark-free, excellent commutation.

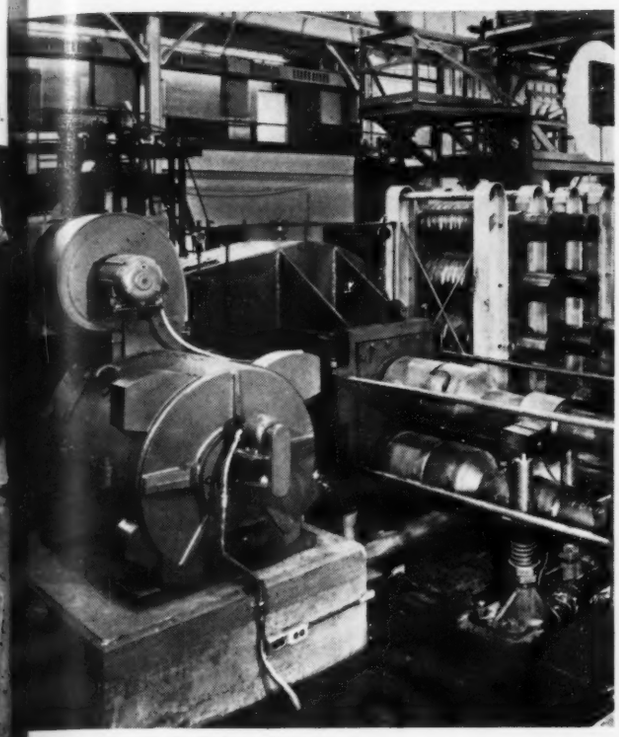
There's much more. Ask for literature which gives complete details.

ELLIOTT COMPANY

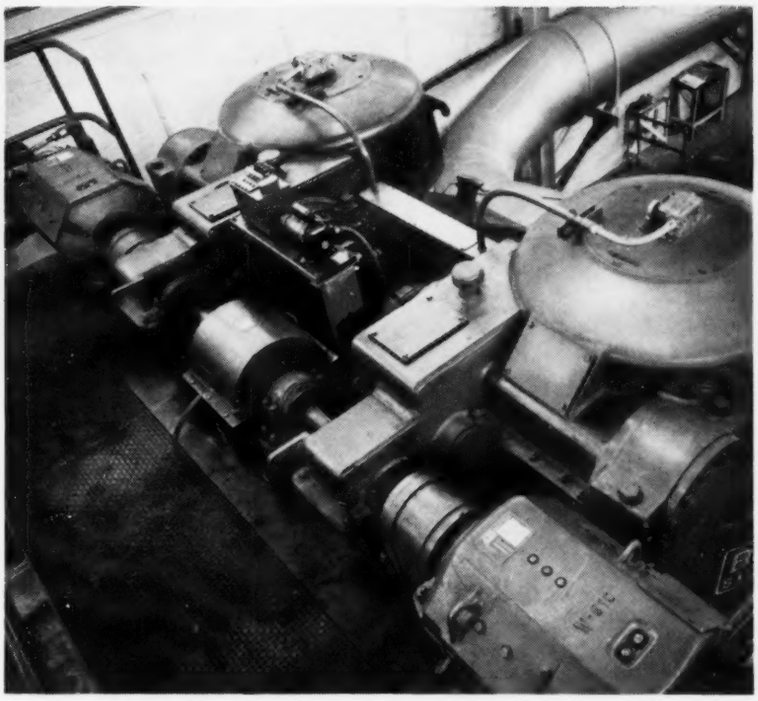
GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS: Jeannette and Ridgway, Pa.; Springfield, Ohio

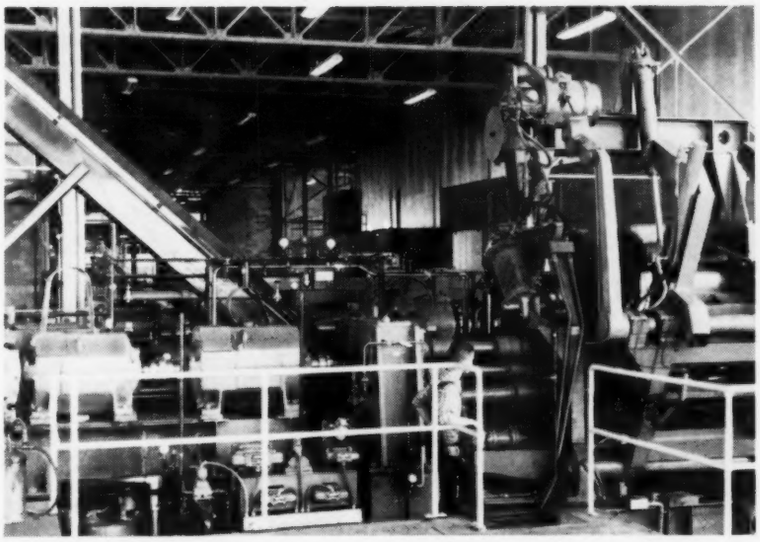
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS



Above: This Elliott 620 mill motor is the main drive for a reversing hot mill in a research laboratory.

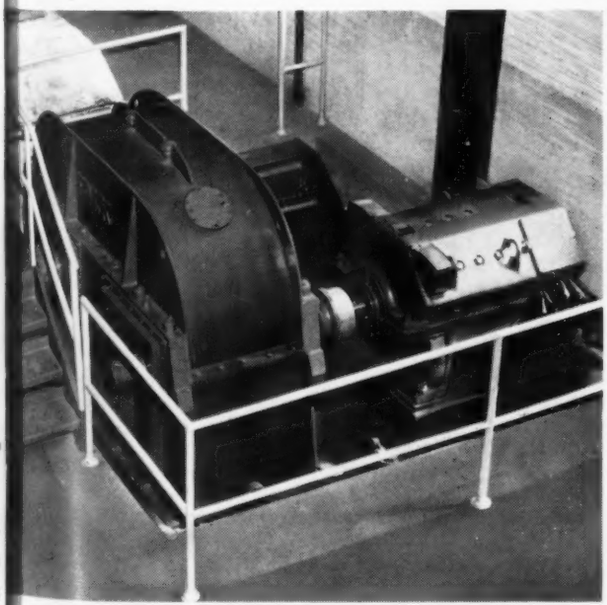


Right: Elliott motors supplying power to drive screw-downs in a reversing cold mill.



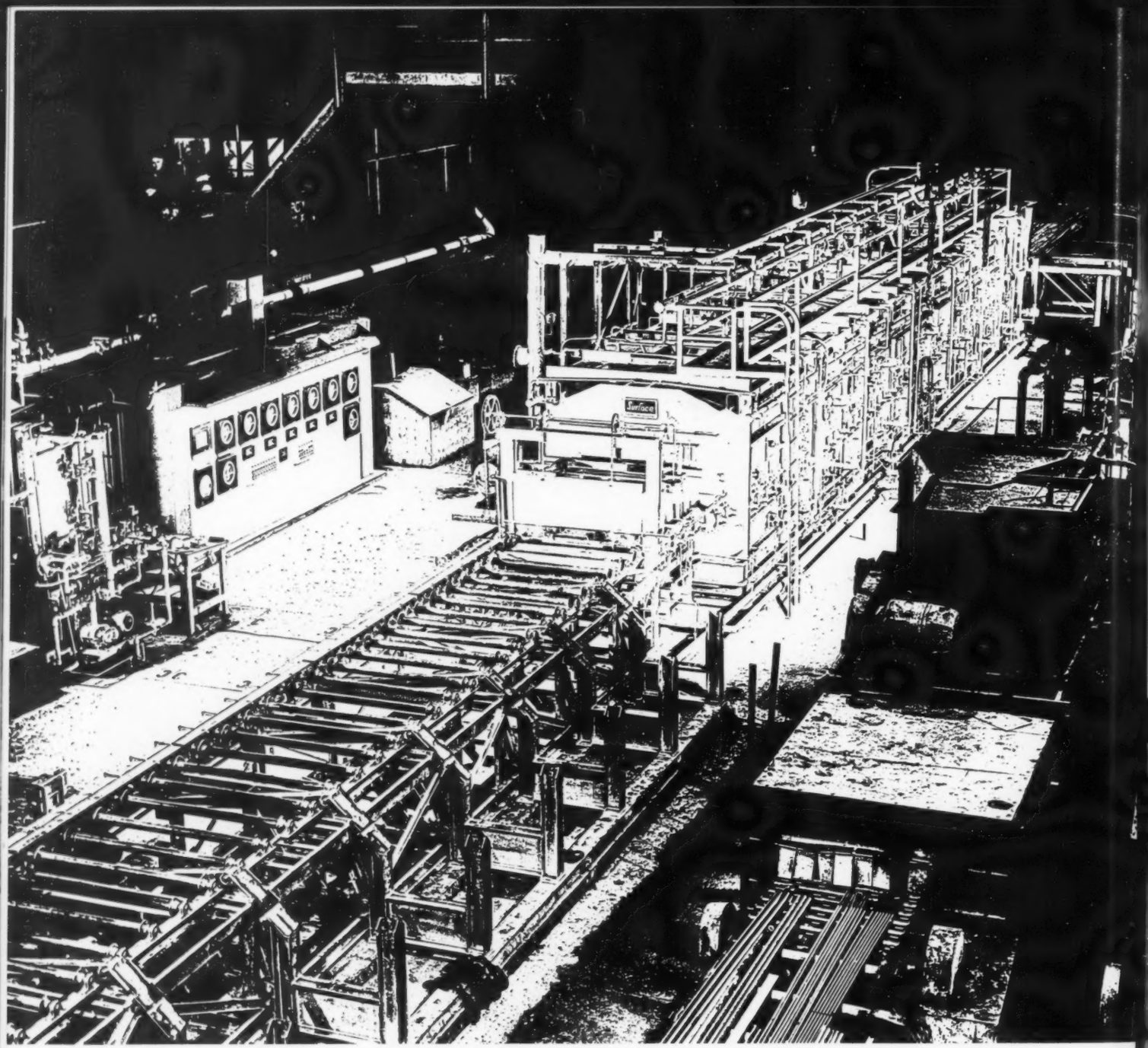
Above: Two Elliott mill motors in tandem driving a slitter and coiler.

steel industry



Left: This Elliott C-W mill motor replaced a steam engine rolling mill drive.

W1-9



Courtesy of Jones & Laughlin Steel Corporation

Produces more steel and happier customers: Both Jones & Laughlin Steel Corporation and its customers have gained from this Surface furnace. For J&L, it affords continuous high production, uniformity through every bar in each load, accurate repeatability, and a variety of heating-cooling cycles. For J&L's customers, it delivers bar stock with the uniform microstructure which improves machining efficiency and profits. Address inquiries to 2404 Dorr St., Toledo 1, Ohio.

SURFACE

SURFACE COMBUSTION, Toledo 1, Ohio/ a division of Midland-Ross Corporation MR

Throughout the steel industry, the Blaw-Knox name means exceptional service and the highest standards of performance. Behind this name are the engineering force and plant capacity necessary to meet steelmakers' most advanced requirements for modern automatic equipment. Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh 22, Pa.

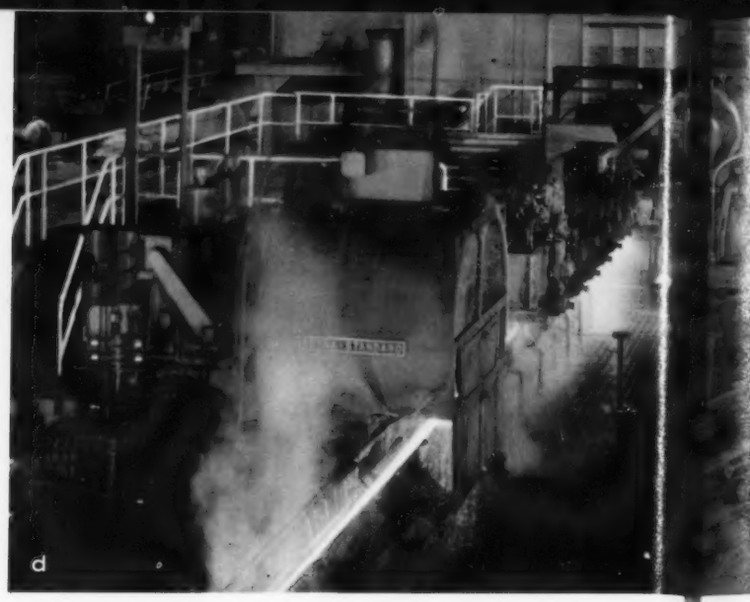
BLAW-KNOX

Rolling Mills and Processing Equipment for Shape Rolled Products

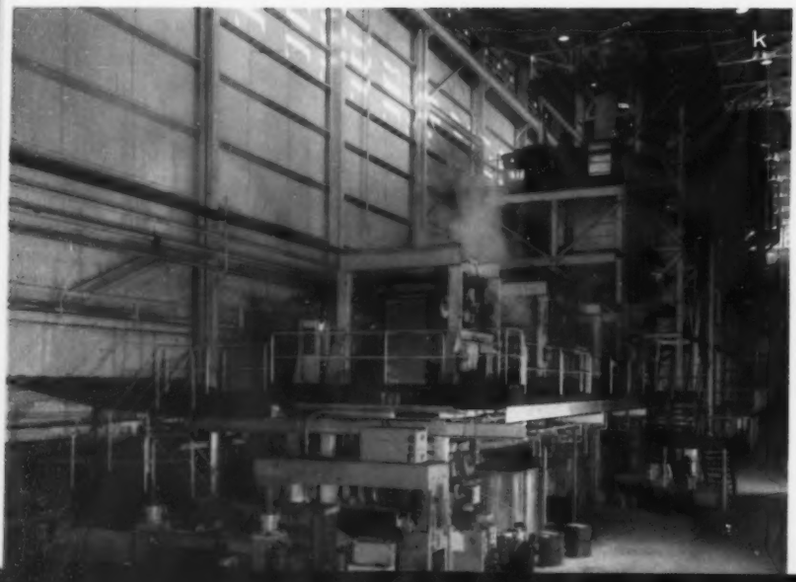
a Combination 46- x 114-inch Blooming-Slabbing Mill and 38- x 53- x 114-inch 4 high Plate Mill. b Wide Flange Beam and Structural Mill. c Merchant Mill.

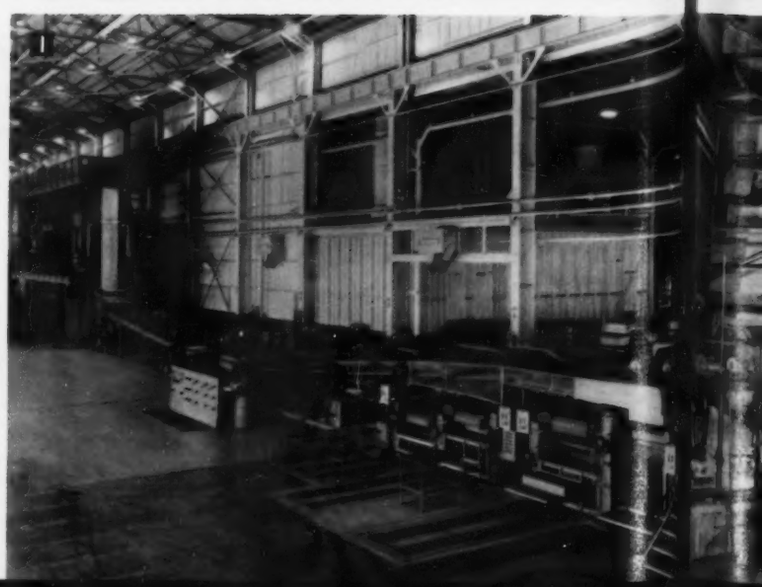
Rolling Mills and Processing Equipment for Shape Rolled Products (Continued)

d Continuous Butt Weld Pipe Mill. **e** High Speed 2-roll Straightener in Cold Drawn Bar Line. **f** Roller Straightener for Hot Rolled Angles.

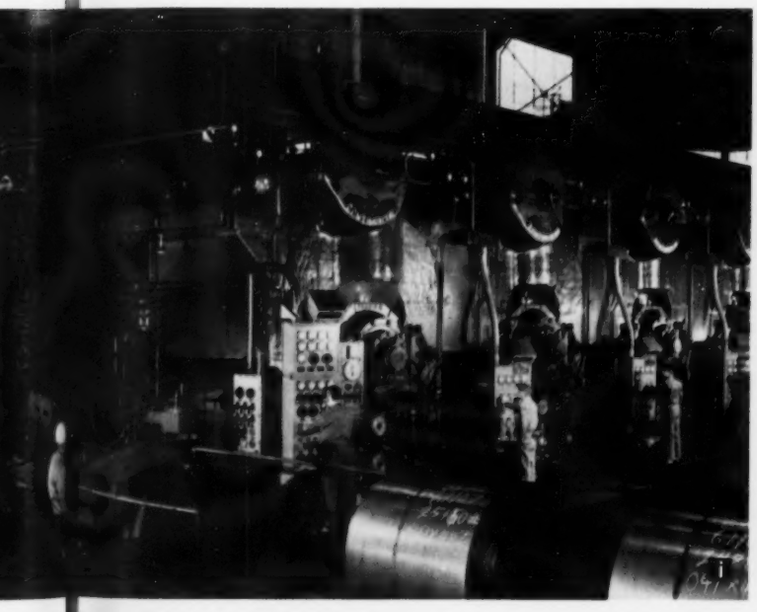


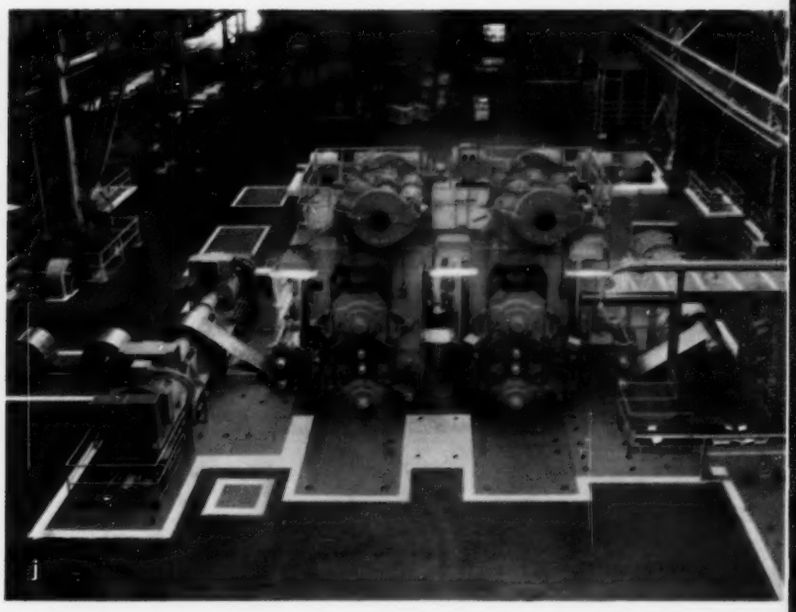
BLAW-KNOX





BLAW-KNOX





Rolling Mills and Processing Lines for Flat Rolled Products

g 46- x 90-inch Universal Slabbing Mill. **h** 56-inch Hot Strip Mill. **i** 60-inch Tandem Cold Strip Mill. **j** 19- and 53-inch x 48-inch Twin Temper Mill. **k** Continuous Annealing Line. **l** Electrolytic Tinning Line. **m** Continuous Galvanizing Line.

n Iron, Alloy Iron, Steel and Alloy Steel Rolls.

o Foundry Products: Peels, Slag Pots, Charging Boxes, Ingot and Charging Cars, Ladles, Trunnions and Rings, Blast Furnace Hoppers and Bells.

p High Alloy Castings: Radiant Tube Assemblies, Furnace Parts, Continuous Annealing, Conveyor, Feeder, Deflector and Zinc Rolls, and Heat Exchanger Elements.

q Steel Plant Equipment: Ladle Additions Feeders, Autopours,® Dolomite Machines, Water-cooled Doors, Frames, and Reversing Valves.

BLAW-KNOX

n

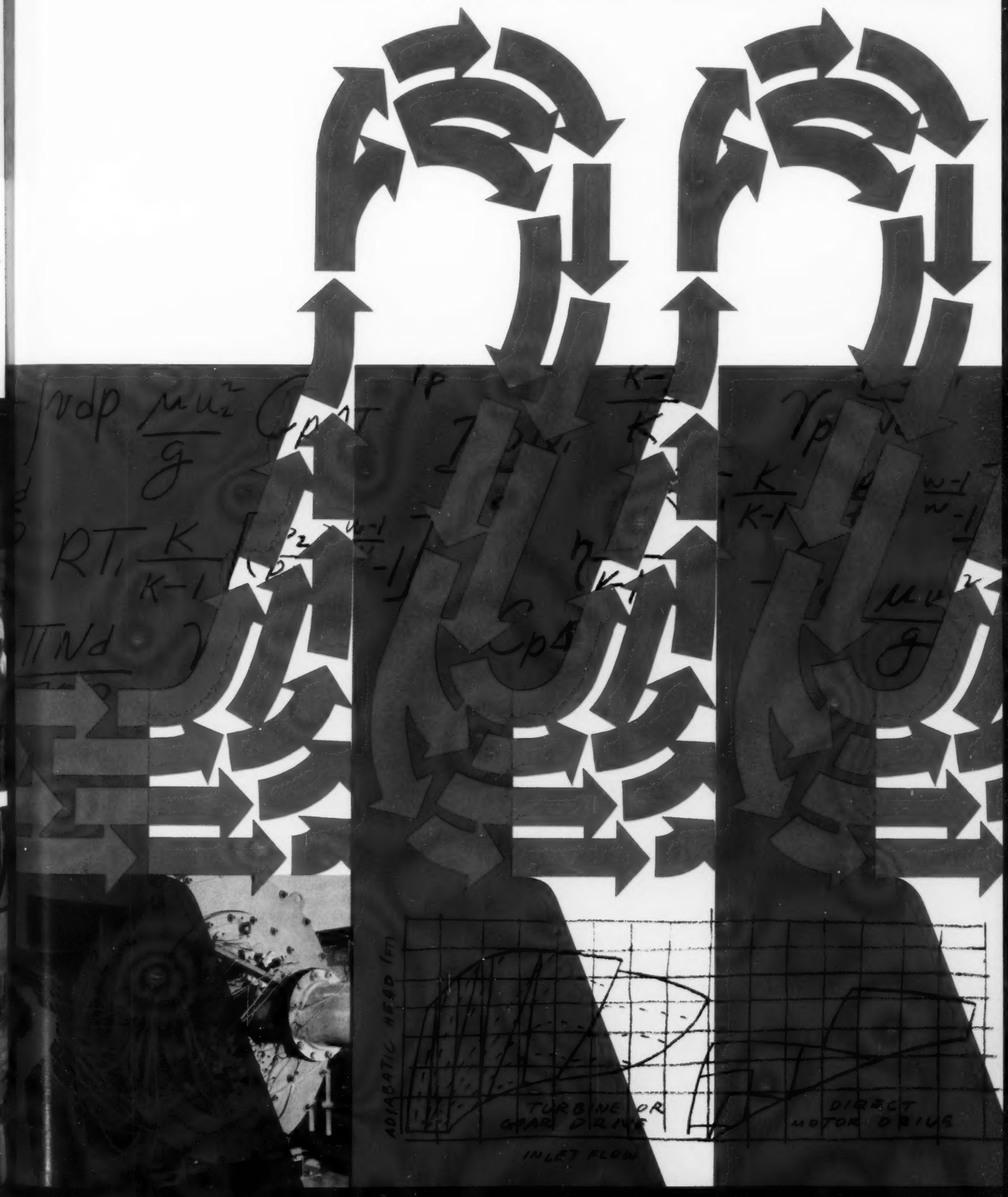
o

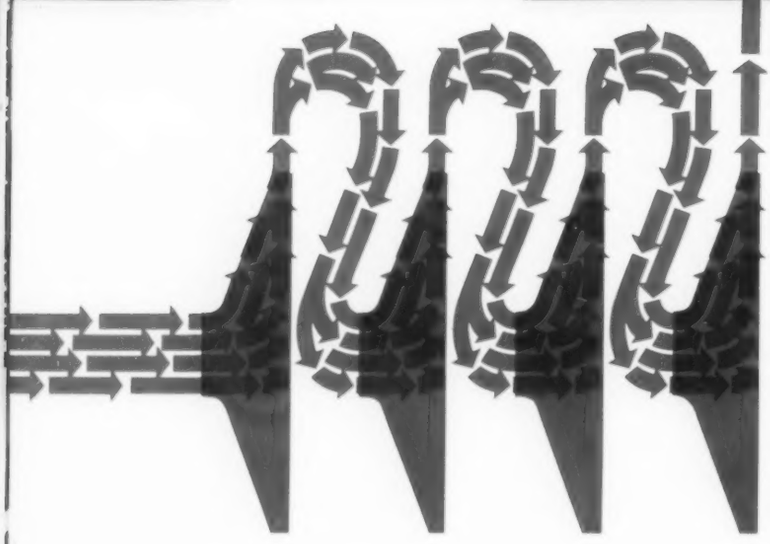
p

q

SOLID FOUNDATION FOR PROGRESS

Engineering Research is the backbone of Elliott developments in centrifugal compressor design. Persistently exploring new paths to broader application flexibility, better operating efficiency, increased reliability, Elliott compressor research engineers study aerodynamic, thermodynamic, mechanical, metallurgical and related subjects to improve and perfect the performance of Elliott compressors. **ELLIOTT COMPANY**





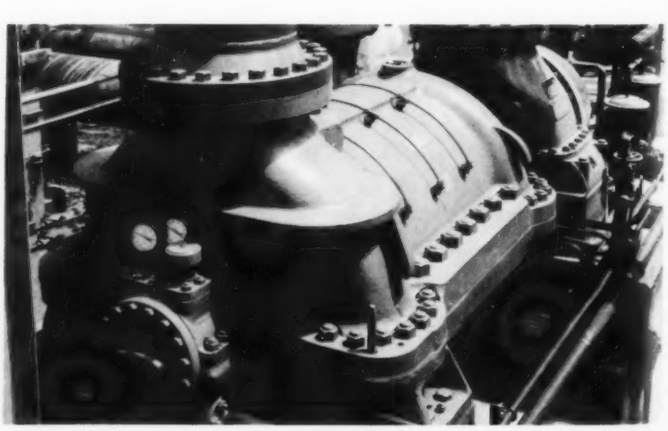
IS BEING DEVELOPED HERE

This is a part of the Elliott compressor development facility—a highly-sophisticated proving ground for new ideas.

With the research equipment pictured here, new compressor wheel designs, new diffuser and return channel patterns, new inlet and discharge geometry can be evaluated. A multiplicity of temperature and pressure probes report conditions at test stations from inlet to discharge. Compressor components under study can be operated as an open air system or as a closed loop.

The knowledge gained with this and other unique research facilities will assure continued advances in the design and application of Elliott compressors.

This is one of the Elliott machines now in service into which has been incorporated fundamental basic knowledge already gained through the use of the above facility.



ELLIOTT COMPANY

ELLIOTT THE MOST COMPLETE LINE OF INTEGRATED COMPRESSOR & DRIVER UNITS 500 cfm to 600,000 cfm

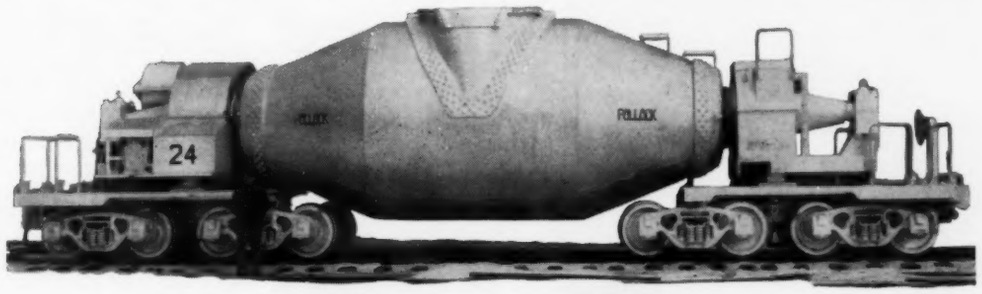
GENERAL OFFICES: JEANNETTE, PA.

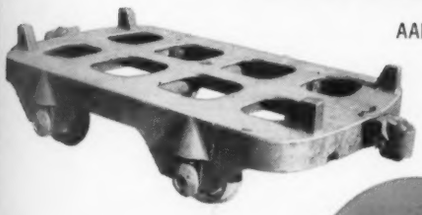
PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS

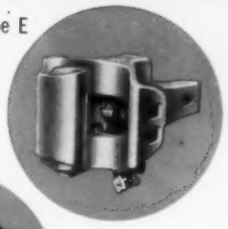
CAR PROTECTION !

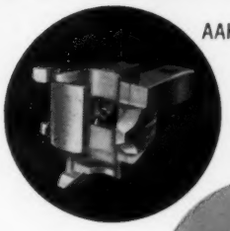
There's a National combination of Coupler and High Capacity Rubber Draft Gear to fit your car and its protection needs. Increase car availability, reduce maintenance time and cost.





AAR Type E





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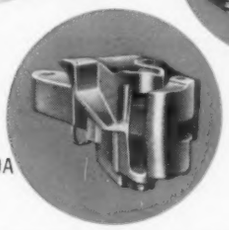
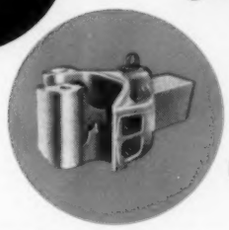
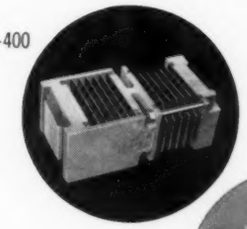


Sharon-10A

NATIONAL COUPLERS

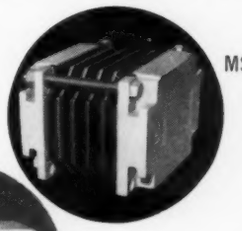


National AP



MF-400

NATIONAL RUBBER DRAFT GEARS



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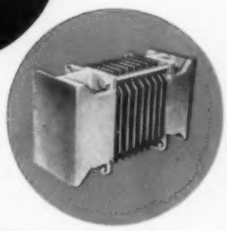

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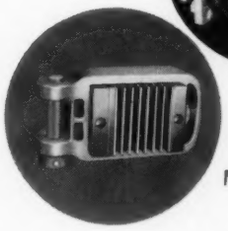

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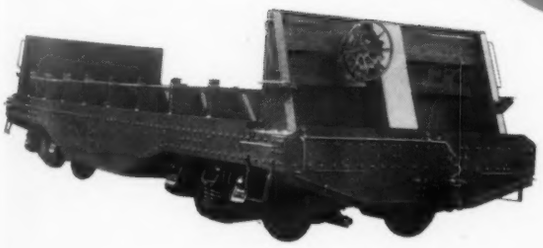

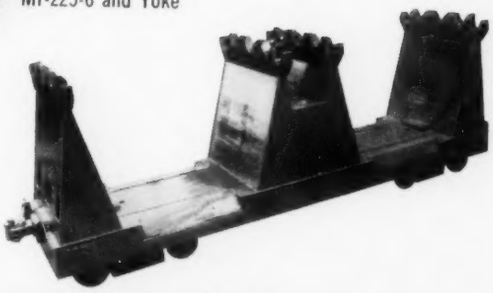

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patent reviews

By Melvin Nord, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period April 18, 1961 to May 16, 1961.

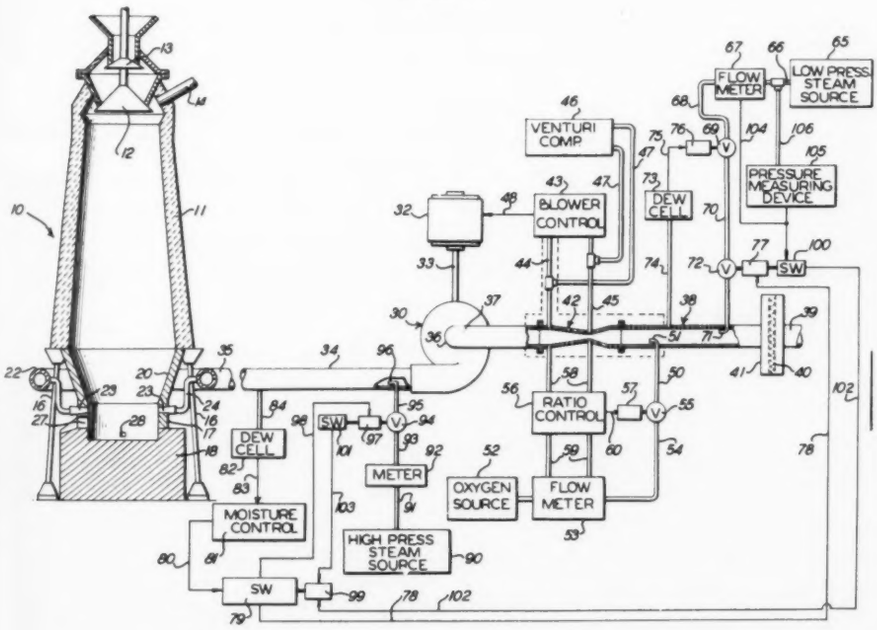
BLAST FURNACE CONTROL APPARATUS

△ U. S. Patent 2,980,416, issued April 18, 1961 to Julius H. Strassburger and assigned to National Steel Corp., provides apparatus for controlling the composition of blast gas for blast furnaces, i.e., the amount of oxygen and moisture in the gas.

Blast furnace installations ordinarily include a number of steam driven prime movers and accordingly a large quantity of exhaust steam at substantially atmospheric pressure is available as an inexpensive source of aqueous fluid for providing the required blast gas moisture. The low pressure exhaust steam may be mixed with atmospheric air fed to the suction side of a compressor for blowing blast gas through the tuyères and into the furnace. Since the quantity of moisture that may be added to blast gas on the suction side of the compressor is limited, for the most part, by the existing temperature, it is not possible to meet the moisture requirements by the use of low pressure steam except when the blast gas is blown to the furnace at relatively low temperature and contains low percentages of oxygen enrichment. High moisture requirements have been satisfied in the past by introducing high pressure steam to blast gas on the discharge side of the compressor. Steam under a sufficiently high pressure for this purpose is not available in blast furnace installations as "waste" steam and the power required to provide an adequate source of high pressure steam constitutes a material expense item in view of the large volume of moisture blown into the furnace during each 24-hr operating period.

The present invention provides a novel apparatus by which the required moisture content of blast gas is obtained in such a manner as to utilize at all times the maximum possible quantity of low pressure steam irrespective of the temperature and natural moisture content of atmospheric air. This is accomplished by the provision of means for adding low pressure steam to blast gas on the suction side of the compressor and for adding high pressure steam to blast gas on the discharge side of the compressor and the provision of a novel control apparatus which functions to maintain a predetermined quantity of moisture in blast gas blown to the furnace irrespective of variations in natural moisture content of the atmospheric air while at the same time insuring that the maximum possible quantity of the moisture in the blast gas is supplied from the source of inexpensive, low pressure steam. The apparatus is shown schematically in Figure 1.

Figure 1



COOLING OF MOVING STRIP

△ U. S. Patent 2,983,497, issued May 9, 1961 to William H. Dailey, Jr., and assigned to Midland-Ross Corp., relates to cooling of strip

steel which has been annealed and cleaned at high temperature preparatory to immersion in a coating pot in a continuous galvanizing line.

The side-to-side temperature uniformity of the strip must be maintained on cooling to avoid stretching the strip to a flat condition when in a relatively plastic state and at an unbalanced temperature condition, and thereafter cooling to a relatively elastic state, bringing the strip to a balanced temperature condition, and forming wrinkles in the strip.

To apply a differential cooling effect side-to-side of the strip and compensate for the inherent cooling characteristics of the apparatus or cooling chamber, a series or bank of longitudinally extending, internally fluid cooled tubular heat sinks is provided, above and below the strip being preferred, and the cooling flow of fluid is adjusted individually, or from tube to tube, to provide a differential applied cooling effect side-to-side of the strip.

In Figures 2 and 3, the apparatus is illustrated as a part of a continuous galvanizing line for strip steel where the strip, represented by a discontinuous line 10, leaving a high temperature cleaning and atmosphere annealing chamber, passes through an entry zone 11, which may include an atmosphere seal, into a cooling chamber 12 and then through a discharge tunnel 15 into a molten bath of zinc 13 in a pot or tank 14 and out therefrom to further processing and cooling. Suitable rolls 16, 17 are provided to support and advance the strip through the apparatus.

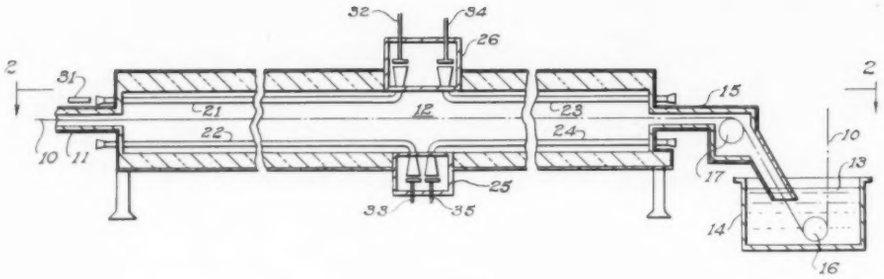


Figure 2

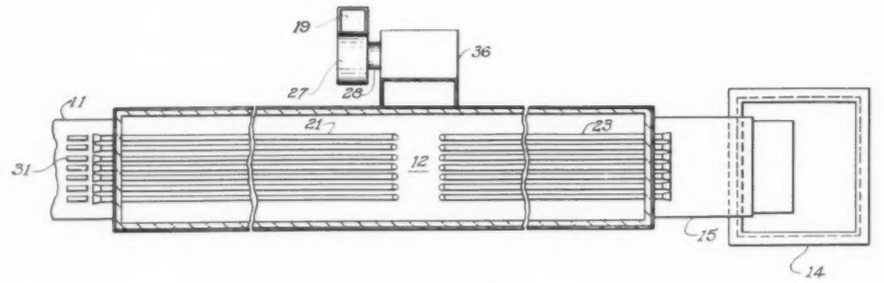


Figure 3

The chamber 12 is formed of gas tight welded sheet metal lined with insulation so that cooling of the strip may be subject to some degree of control. Cooling of the strip passing through the chamber is effected by tubes 21, 22, 23 and 24 arranged in banks above and below the strip. Air is caused to flow through these tubes, thus cooling the tubes. To simplify the mechanism for causing coolant air to flow, the tubes 21, 22, 23 and 24 are arranged with their respective inlet ends at the respective ends of the cooling chamber 12 and their outlet ends discharging into manifolds 25, 26 located centrally of the cooling chamber. The manifolds 25 and 26 lead through duct 36 to the intake side 28 an exhauster blower 27, thus imposing a reduced pressure on the outlet ends of the tubes and causing draft therethrough to a stack 19. The tubes are thus operated at a reduced pressure, hence if any leaks develop in the tubes within the cooling chamber, atmosphere from within the chamber will leak into the tubes, and the cooling chamber atmosphere will not be contaminated by the cooling air.

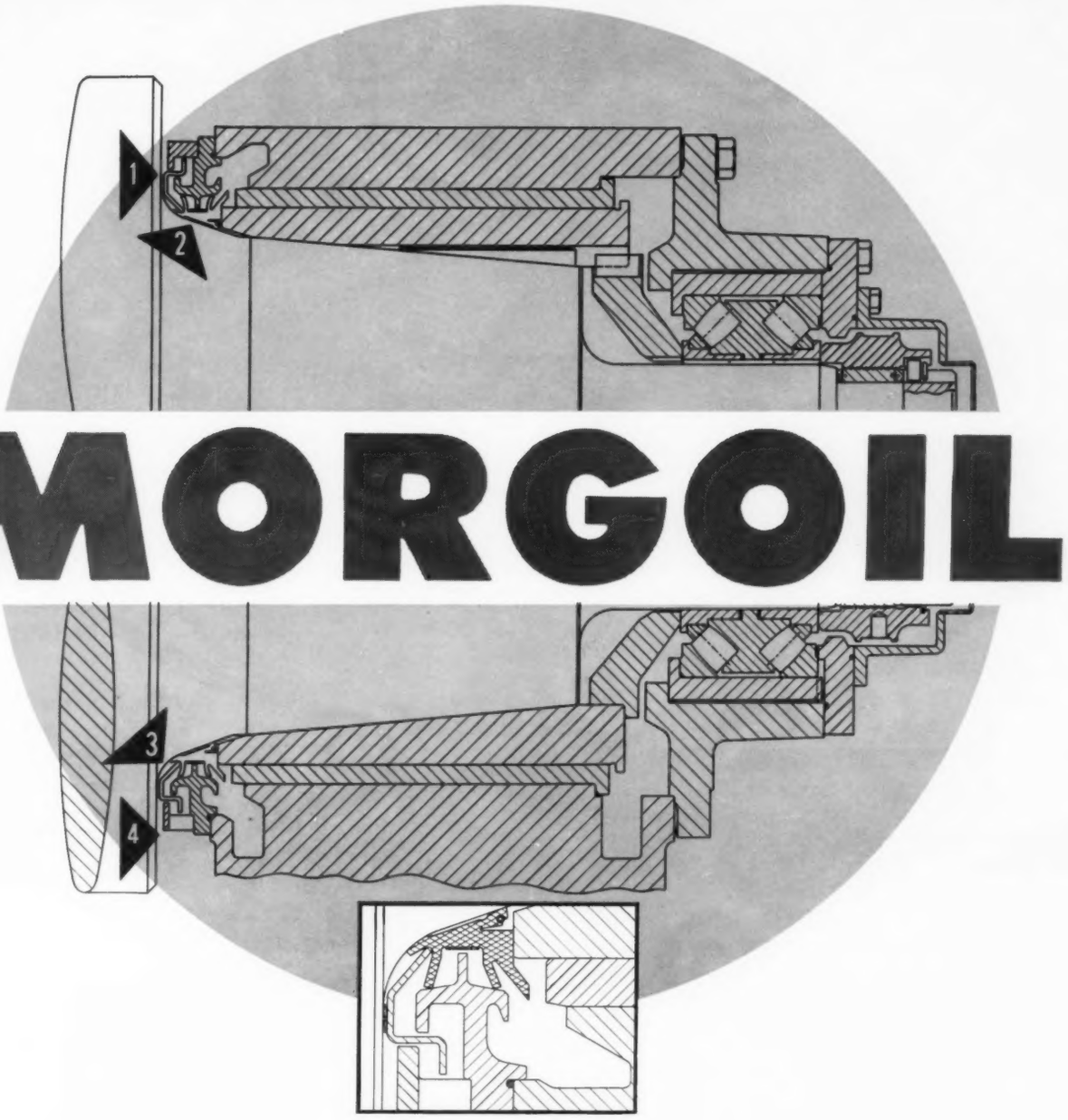
The individual tubes are provided with draft controls by valves 32, 33, 34 and 35, operable manually, or the valves may be operated automatically responsive to downstream strip temperature. Individual tubes may be provided with a fuel nozzle at its end, like nozzles 31 shown at the inlet of tubes 21, constituting the tubes heaters for initial warming of the cooling chamber, and the valves 32 are then utilized to control draft through the tubes to obtain a proper proportion of combustion air.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,981,419	4/25/61	Billet handling apparatus.....	Odin Corp.
2,981,423	4/25/61	Charging horizontal coke ovens	Woodall-Duckham Construction Co., Ltd.
2,981,532	4/25/61	Sintering machine.....	McDowell Co., Inc.
2,982,018	5/ 2/61	Welding of nine per cent nickel-steel plates.....	Lukens Steel Co.
2,982,533	5/ 2/61	Sintering apparatus.....	Metallgesellschaft, A.G.
2,982,534	5/ 2/61	Rotary electric furnace.....	Demag-Elektrometallurgie G.m.b.H.
2,983,598	5/ 9/61	Corrosion-resistant steel.....	A. O. Smith Corp.
2,983,601	5/ 9/61	High-speed tool steel.....	Latrobe Steel Co.
2,984,285	5/16/61	Apparatus for removing camber from metal strips.....	Acme Steel Co.
2,984,474	5/16/61	Annealing furnace for stainless steels.....	Armco Steel Corp.
2,984,563	5/16/61	Stainless steel.....	Harry Tanczyn
2,984,592	5/16/61	Protective coatings for galvanized sheets.....	Chem-Metals, Inc.

CONTROLLING STRIP GAGE

△ U. S. Patent 2,983,170, issued May 9, 1961 to Frank Slamar and assigned to United States Steel Corp., provides apparatus controlling the speeds of the mill stands so that hot-rolled strip of uniform gage will be produced. More specifically, the invention concerns apparatus acting in response to temperature variation along the length of the strip passing through the mill to adjust the speeds of the several stands and, therefore, the tension on the strip between stands, so that the gage of the finished strip is held constant within narrow tolerances.



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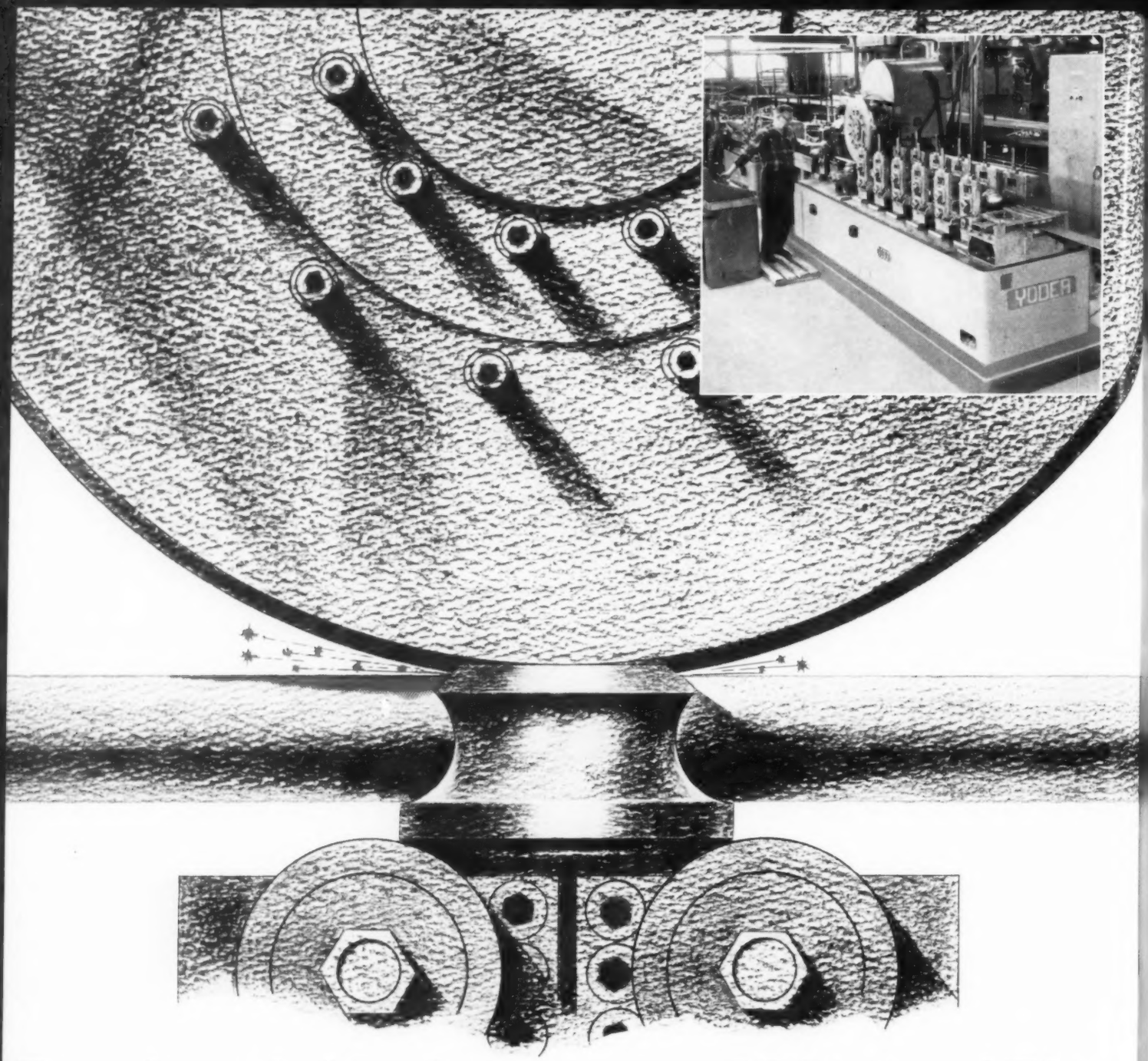

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The present invention provides a control system for measuring the temperature of successive points along the strip as it is being rolled and correspondingly varying the speeds of the latter stands of the mill so as to effect changes in the inter-stand tension on the strip which will compensate for changes in the temperature of the strip from point to point therealong. It also employs a gager responsive to the thickness of the finished strip, to effect an adjustment of the temperature-measuring means as necessary. The variation in the speeds of the several mill stands is effected by modifying the action of conventional speed regulators for the motors individually driving the several stands. The apparatus is shown schematically in Figure 4.

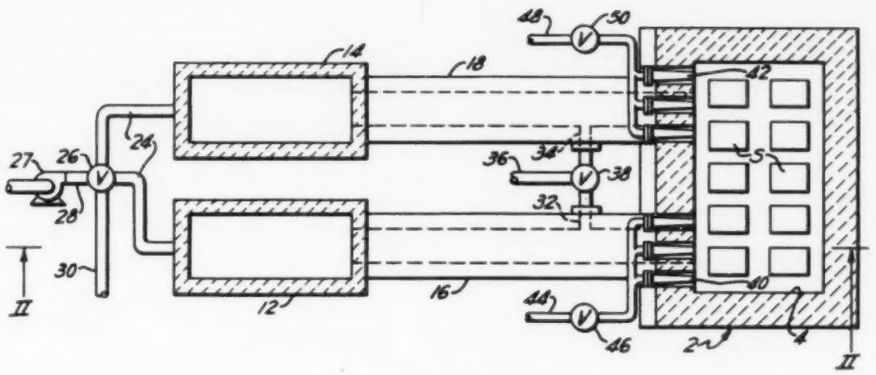


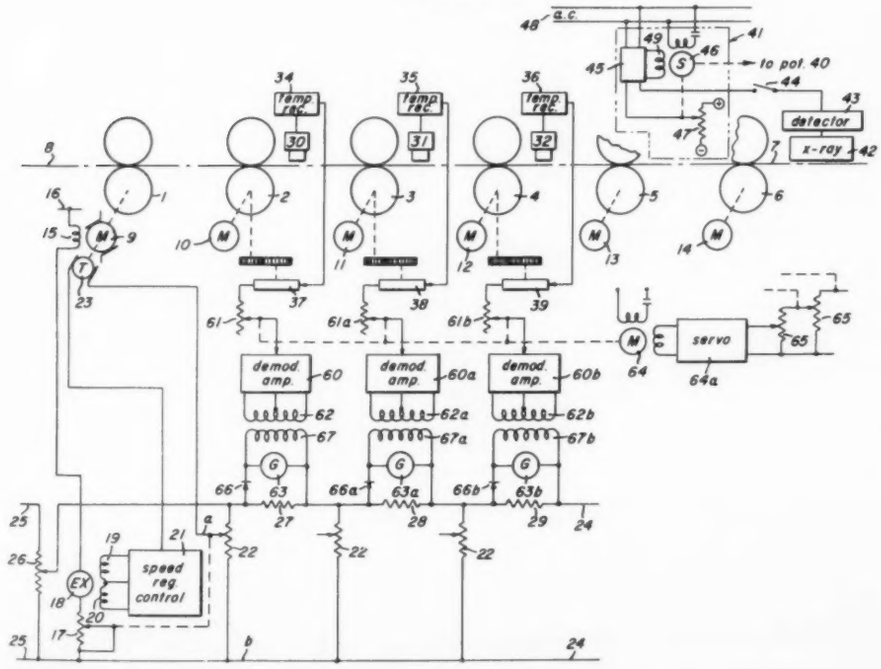
Figure 5

APPARATUS FOR HEATING INGOTS

△ U. S. Patent 2,983,499, issued May 9, 1961 to Clarence W. Sidwell and assigned to United States Steel Corp., provides apparatus for heating steel ingots prior to rolling, by means of soaking pits utilizing high calorific fuel such as natural or coke-oven gas.

As shown in Figure 5, the ingots S are charged into the chamber 4 and valve 26 is arranged so that air is drawn through the flue 16 to the chamber 4. The valve 38 is set so that the fuel passes through port 32 into the flue 16 where it burns and gives added preheat to the air above the ingot temperature prior to its entry into the chamber 4. This prevents chilling of hot ingots. Fuel is also delivered to the chamber 4 through burner ports 40 and 42. After a period of time which may be between three to ten min, the valves 26 and 38 are reversed so that air is heated in the regenerator 14 and the flue gas passed outwardly through the flue 16 and regenerator 12. The air passing through the flue 18 is heated by fuel from the burner 34 and no fuel enters the flue 16 through the burner 32. The cycle is then repeated until the ingots reach the desired temperature. Control of fuel to the burners 32, 34, 40 and 42 may be varied according to the requirements of the heating cycle. During the early heating stages all of the heat may be provided by burners 32 and 42 alternately, and at all times at least part of the heat will be provided by these burners. After the ingots become hotter additional heat will be provided from the burners above the flue providing air. At the same time still additional heat may be provided from the other set of top burners.

Figure 4



PORCELAIN ENAMELING OF FERROUS METAL

△ U. S. Patents 2,981,633 and 2,981,634, issued April 25, 1961 to Shipp C. Davis and William G. Ray, assigned to Charles Pfizer and Co., Inc., provide processes for the porcelain enameling of ferrous metal objects.

The metal is cleaned and then pickled with citric acid solution at 160 to 212 F for 5 to 30 min. Nickel is then deposited on the surface. The object is then coated with porcelain enamel, dried at 250 to 400 F and baked at 1300 to 1550 F for three to six min.

ANNEALING COILS OF METAL STRIP

△ U. S. Patent 2,983,502, issued May 9, 1961 to Robert E. McClure, Jr., and assigned to United States Steel Corp., provides a method of heating coils of metal strip for annealing purposes.

A coil is placed with its axis vertical on a bearing surface. On this coil is placed a pair of bearing plates spaced apart, one above the other. A second coil is placed on these plates. The resulting stack is enclosed. A combustible gas mixture is ignited around the space between the above pair of plates, and the burned gases are exhausted.

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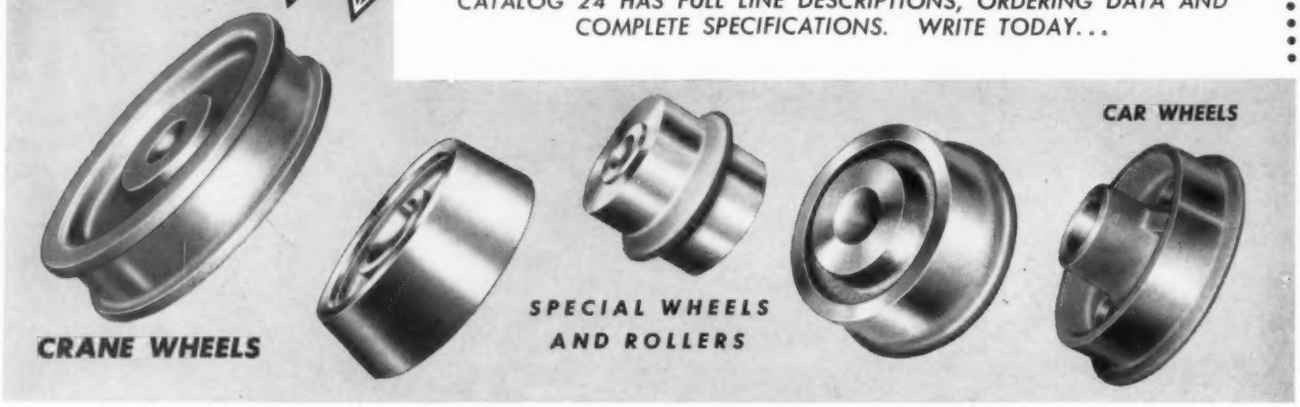

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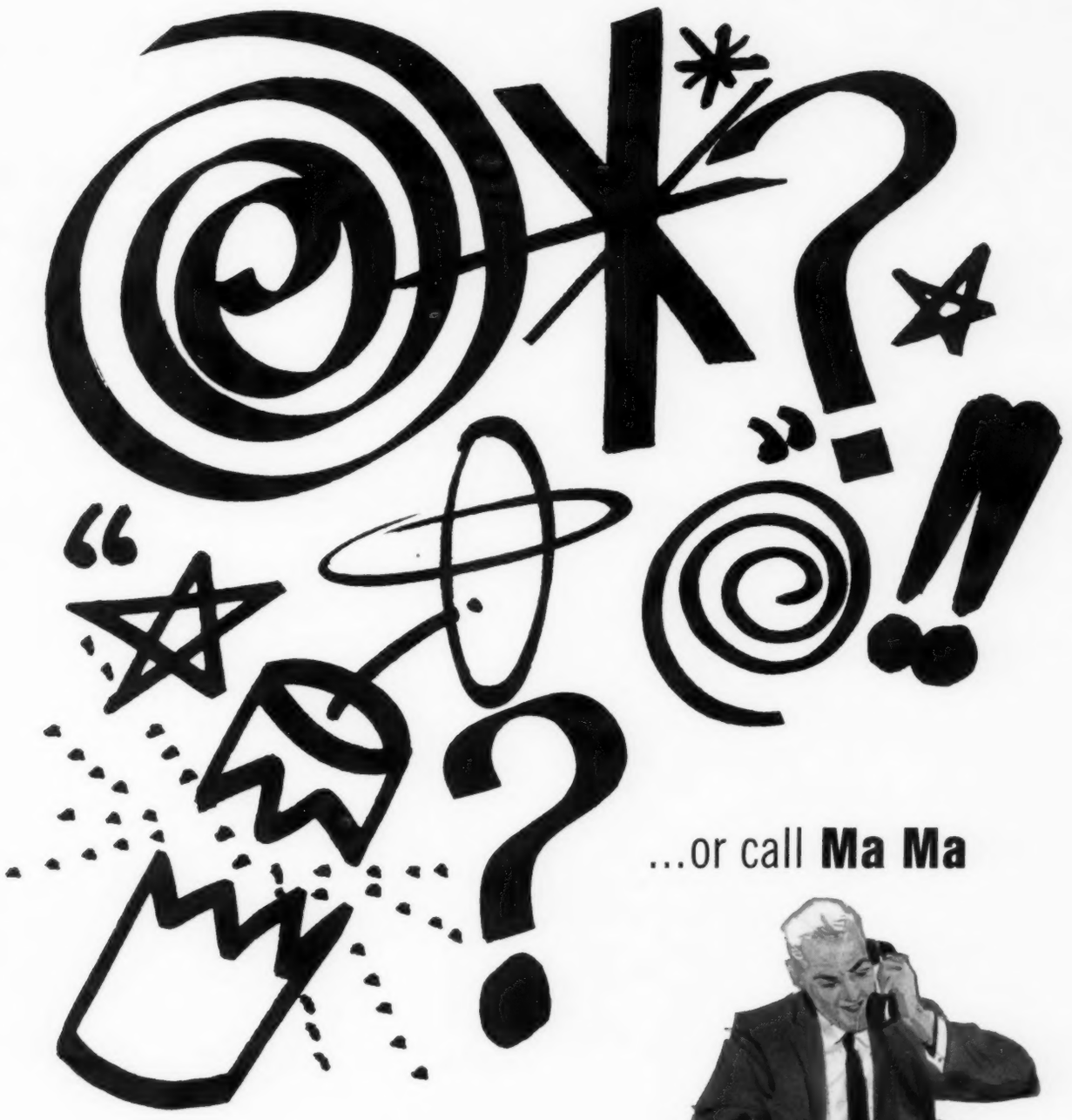

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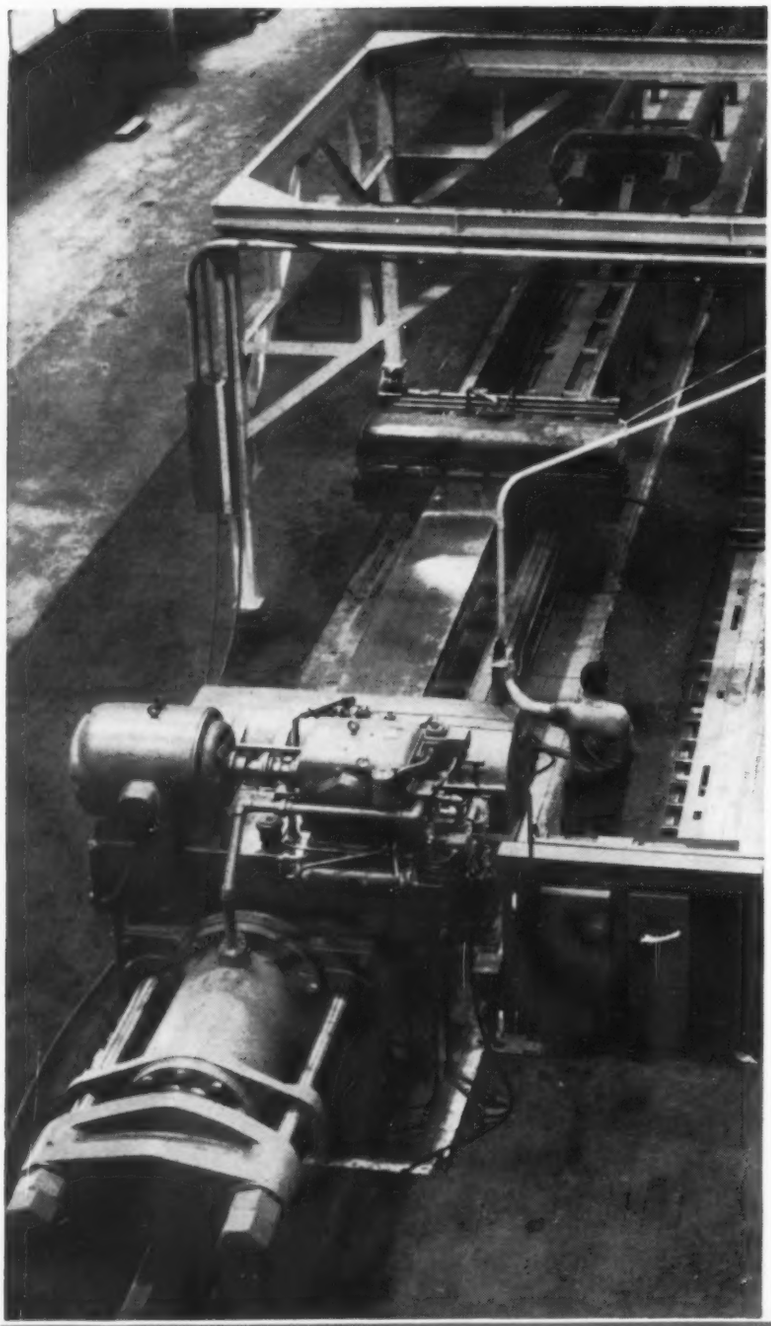

Photo courtesy of Anaconda Aluminum Company also shows Vacu-Lift equipment.

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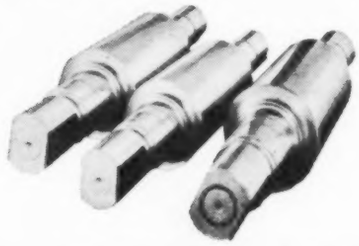

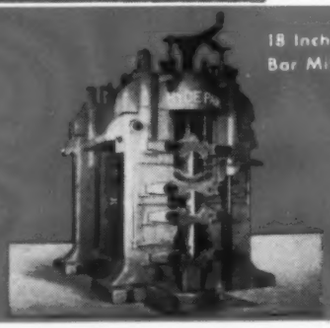

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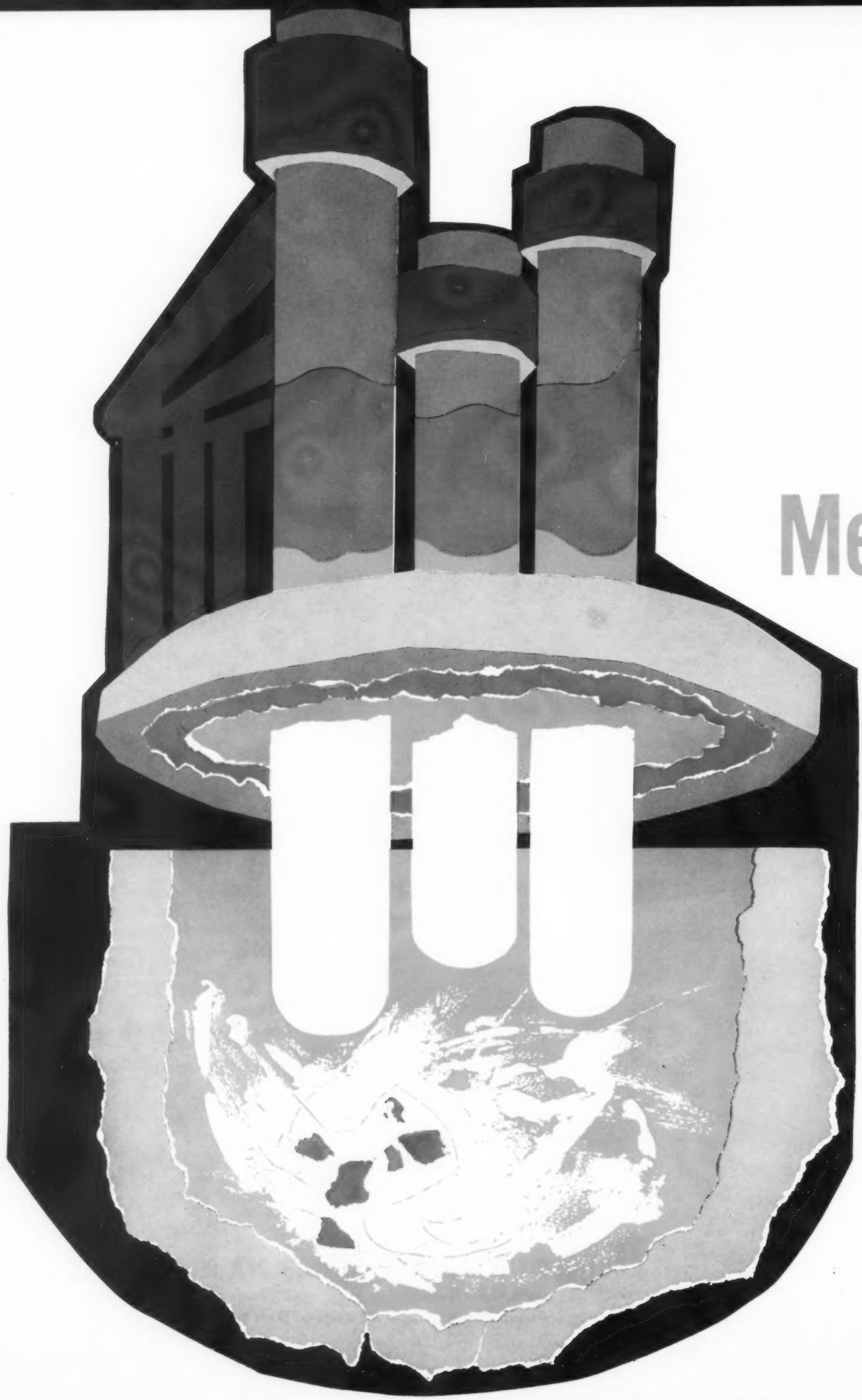

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Here is automation at its smoothest. With only a handful of men in efficient control pulpits, the plant can turn out blooms of many shapes and sizes.

Heart of the operation is a new, 40" x 90" high-lift blooming mill, whose rolls are automatically set for each pass by punched cards. Taking the ingots poured by the new 100-ton electric furnace, it rolls them into the size required.

Of special interest is the mill's unusually versatile design. Thanks to it, the plant is able to handle round shapes as well as blooms and slabs, simply by changing the rolls. The latter were supplied by Bliss' Mackintosh-Hemphill Division.

According to the plant superintendent, this new plant has increased the company's melting and rolling capacity a full 50%. And based on its proven operating performance, the new Bliss mill will be ready to take any additional new load in stride.

Whether your plans call for a big outlay or a modest one, it will pay you to discuss them with Bliss. To learn how other firms have . . . and have profited . . . write for our 84-page Rolling Mill Brochure, Bulletin 40-B.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Rolling Mills • Mill Auxiliaries • Amerigear/Bliss Flexible Spindles

Subsidiaries: E. W. Bliss (Canada) Ltd.; E. W. Bliss (England) Ltd.; E. W. Bliss Co. (Paris) France; E. W. Bliss-Henschel G. m. b. H., Düsseldorf, West Germany; The Matteson Equipment Company, Inc., Poland, Ohio

Seventy-ton ladle takes molten iron from Whiting continuous hot blast cupolas and pours it into converters.

It's Foxboro control for giant new Acme steel plant

Hot Blast Cupolas have capacity of 50 tons per hr. – operate continuously

Cupolas 67 ft. high by 10 ft. in diameter – the world's largest – are under Foxboro control at Acme Steel's new 35 million dollar plant at Riverdale, Illinois.

To keep hot blast cupolas operating at peak efficiency, Acme depends on Foxboro instrumentation. Foxboro temperature, pressure and flow recorders and controllers to keep air leaving preheaters at a constant 1200F. And Foxboro Air Weight Controllers, that meter blast air by weight instead of volume,to help cut fuel costs.

Furnaces, cupolas, preheaters — you'll find Foxboro instruments help operate them all more efficiently. Ask your nearby Foxboro Field Engineer for recommendations for your plant. Or write direct for a copy of Bulletin 13-18. The Foxboro Company, 589 Neponset Ave., Foxboro, Massachusetts.

Small-case Foxboro Consotrol* instruments (foreground) record and control preheater pressures, temperatures, flows. Preheaters were designed by Fabricating Engineering Co., Inc. **Reg. U. S. Pat. Off.*

FOXBORO

REG. U. S. PAT. OFF.

Photo courtesy Jones & Laughlin Steel Corp., Pittsburgh

FOR EVERY APPLICATION, THERE'S ONE CRANE OUTSTANDING . . . P&H!

This wide-span P&H overhead crane is equipped with a trolley-mounted cab so the *operator stays right above the load at all times.* He can clearly see to move and load coils of steel or stacks of plate with unquestioned safety and accuracy. In addition, the P&H Hook-a-Weigh electronic crane scale, in combination with a motorized hook, enables the crane operator to both weigh loads and rotate them safely and precisely. This means faster shipping and easier spotting.

Here, as in every P&H crane installation, Harnischfeger engineers have carefully considered all the factors that affect performance. P&H cranes are built from standard components —yet are individually engineered for the job. Your particular material-handling requirements are integrated right into the overall design. Result: Costs are kept low—but performance is unbeatable.

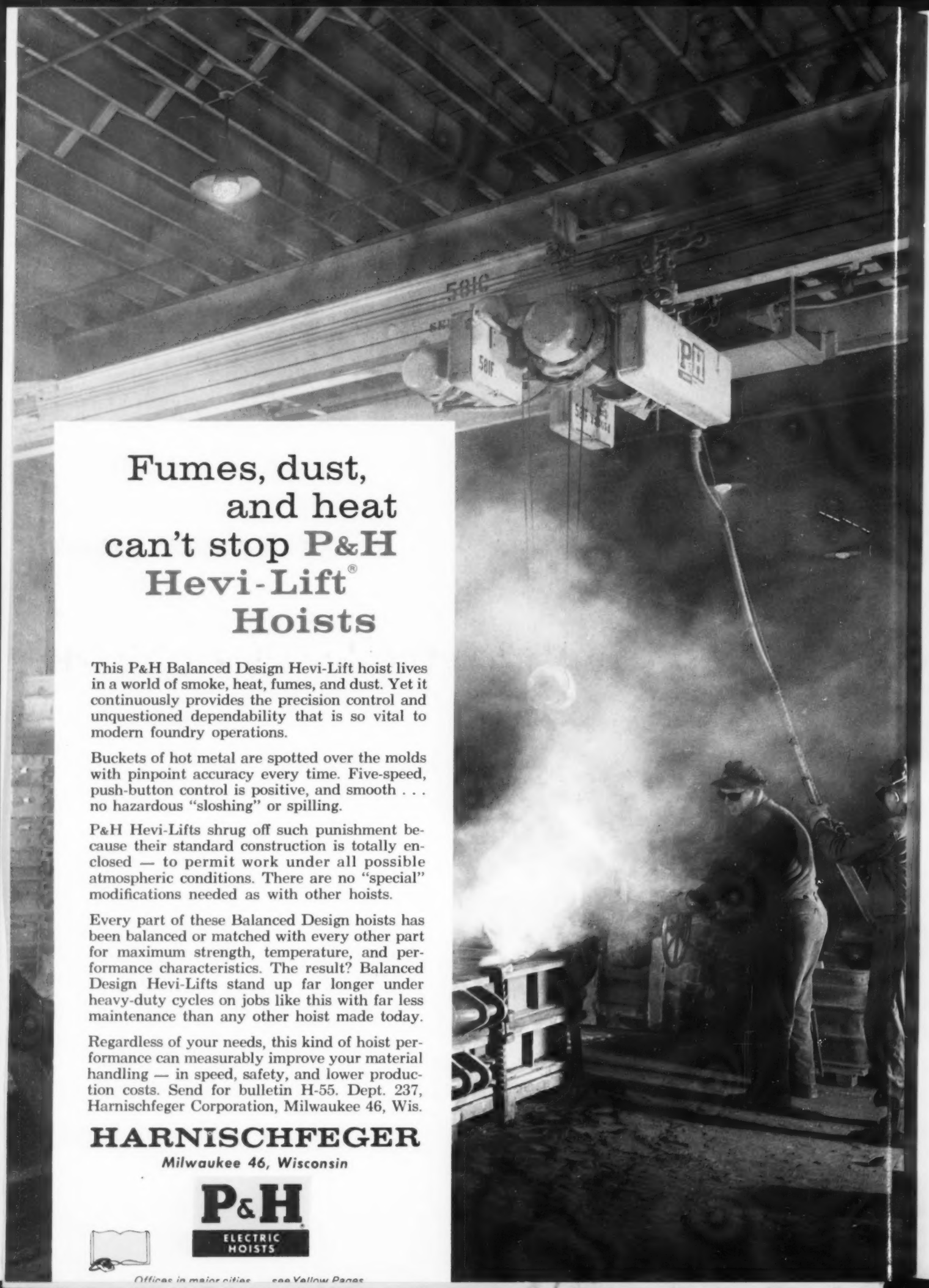
Whether you need 3-ton or 300-ton capacity, it will pay you to find out more about P&H job-engineered overhead cranes . . . and what they can mean to your plant operation. Get a helpful recommendation on your next crane inquiry — send it to Harnischfeger!

P&H Hook-a-Weigh transforms the crane hook into a sensitive, accurate electronic scale. It easily combines weighing and handling operations — eliminates floor-mounted scale equipment. It also maintains an accurate, permanent record on tape or card. Can be used on any crane — capacities up to 200,000 lbs. Another useful feature, the motorized hook, can be combined with Hook-a-Weigh or offered separately, to enable the crane operator to rotate the load at the push of a button, eliminating in many cases the need for floor help.

HARNISCHFEGER
Milwaukee 46, Wisconsin

P&H
OVERHEAD CRANES

Offices in major cities... see Yellow Pages



Fumes, dust, and heat can't stop P&H Hevi-Lift® Hoists

This P&H Balanced Design Hevi-Lift hoist lives in a world of smoke, heat, fumes, and dust. Yet it continuously provides the precision control and unquestioned dependability that is so vital to modern foundry operations.

Buckets of hot metal are spotted over the molds with pinpoint accuracy every time. Five-speed, push-button control is positive, and smooth . . . no hazardous "sloshing" or spilling.

P&H Hevi-Lifts shrug off such punishment because their standard construction is totally enclosed — to permit work under all possible atmospheric conditions. There are no "special" modifications needed as with other hoists.

Every part of these Balanced Design hoists has been balanced or matched with every other part for maximum strength, temperature, and performance characteristics. The result? Balanced Design Hevi-Lifts stand up far longer under heavy-duty cycles on jobs like this with far less maintenance than any other hoist made today.

Regardless of your needs, this kind of hoist performance can measurably improve your material handling — in speed, safety, and lower production costs. Send for bulletin H-55. Dept. 237, Harnischfeger Corporation, Milwaukee 46, Wis.

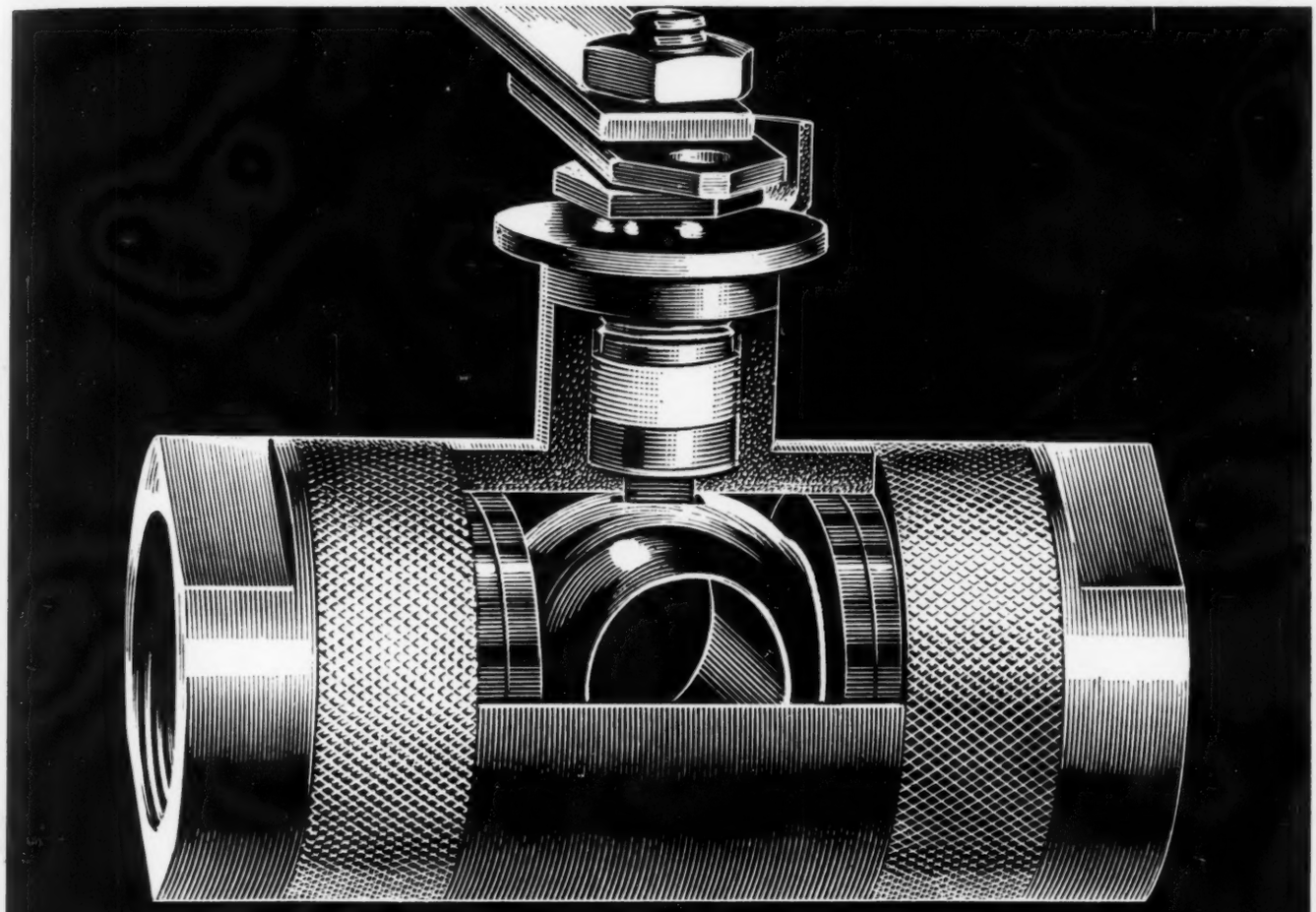
HARNISCHFEGER

Milwaukee 46, Wisconsin

P&H

ELECTRIC HOISTS

Offices in major cities — see Yellow Pages



NEW HOMESTEAD® BALL VALVES

...for almost any fluid in the world!

You have no corrosion problem with Homestead's new Ball Valves, because they are offered in the right combinations of seals and metals for almost any fluid in the world. No leakage problem, either, because Homestead's self-adjusting ball and flexible seal stop flow in either direction. Adjustable packing gland prevents leakage to the outside of valve, too. You'll like Homestead Ball Valves' quarter-turn operation; choice of full round pipe-sized passage or restricted area in either bar-stock or slip-out design, and flow direction indicator that stays on when handle is removed. What's more, you'll find that all of these features add up to lower cost-per-year valve service. For full details, write for free catalog, Reference Book 39-5.

hv

HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving since 1892"
P.O. Box 160 — Coraopolis, Pennsylvania

Makers of Homestead Ball Valves, Cam-Seald, Lever-Seald, and Lubricated Plug Valves

This mark tells you a product is made of modern, dependable Steel.

949 tons of tin product rolled in eight hours on USS Quality Forged Rolls

Not long ago, a crew on the 5-stand cold reduction mill at U. S. Steel's giant Fairless Works rolled out an impressive 949 tons of tin product in a single 8-hour shift.

The mill was equipped with USS Quality Forged and hardened rolls, as might be expected. But you should know that no U. S. Steel mill is obligated to buy rolls from the company if competitive rolls will give better performance. Here is the heart of the story: based on careful long-range performance figures, the USS forged rolls are equal to or better than any other on the market.

As a major steel producer, U. S. Steel is able to continually test the quality of its rolls. Even further, U. S. Steel buys rolls from other manufacturers—for an evaluation of our product. Over and over again, records have shown that USS Quality Forged Rolls have improved wear resistance, and a high degree of cleanliness.

There is a good possibility that we can help reduce your roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation · Columbia-Geneva Steel Division · Tennessee Coal and Iron Division · United States Steel Export Company

USS United States Steel

TRADEMARK

NO PLACE TO GAMBLE...

Joints on this water line at steel plant are TAPECOATED to provide protection equivalent to coating on the pipe.

You take no chances when you specify TAPECOAT coal tar coating in handy tape form for pipe, pipe joints, fittings, couplings, tanks, tie rods and conduit on new construction, as illustrated, or for preventive maintenance on replacements.

Since 1941, TAPECOAT has proved its superiority in resisting moisture, acids, alkalis, chemical fumes and other severe corrosive and abrasive conditions.

For example, failure of a water line at an eastern steel plant in 1946 prompted this producer to turn to TAPECOAT for protecting the new line. Results were so conclusive that they have since standardized on TAPECOAT for wrapping fire prevention, water, gas and fuel lines in sizes ranging from 2″ to 48″.

TAPECOAT comes in rolls of 2″, 3″, 4″, 6″, 18″ and 24″ widths. It is easy to apply with the use of a torch. No skilled help required.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for details today.

The TAPECOAT® Company

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

1541 Lyons Street, Evanston, Illinois

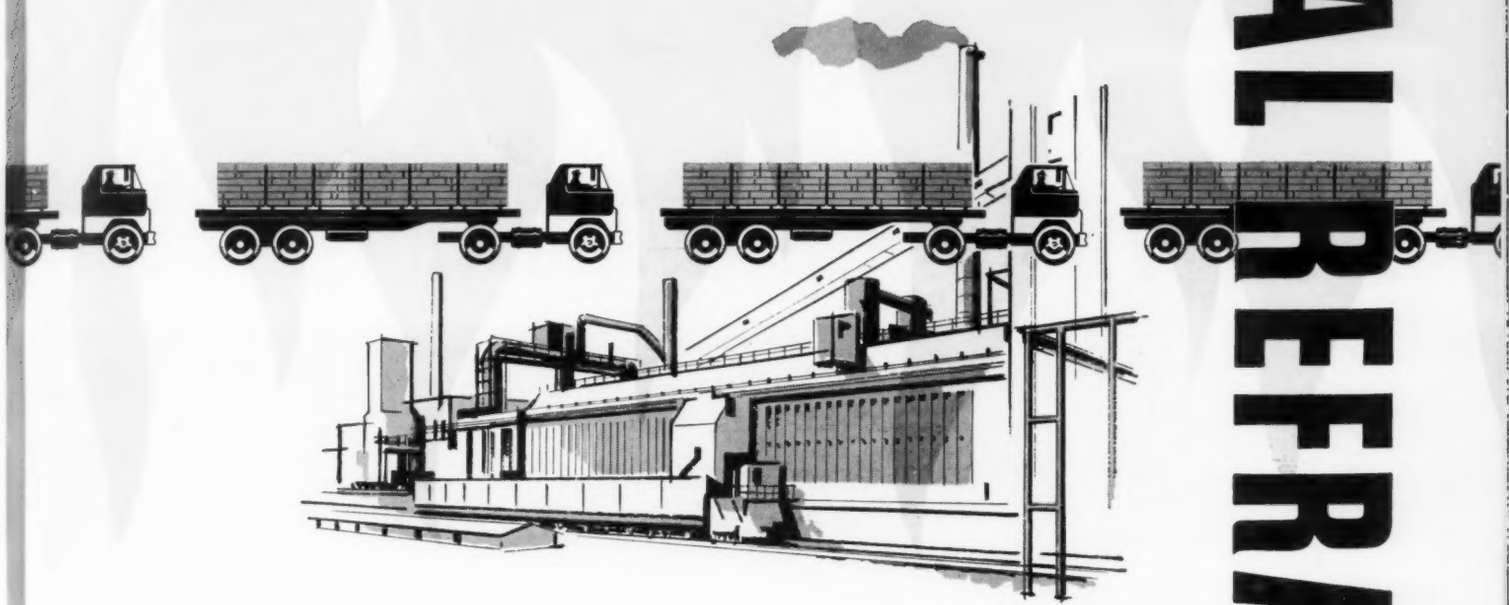
Representatives in Principal Cities

Manufactured and distributed in Canada by The Tapecoat Company of Canada, Ltd., 25 Haas Road, Rexdale, Ontario

GENERAL REFRACTORIES

It takes a lot of know-how to supply millions on millions of brick for thousands on thousands of coke ovens

... GREFCO KNOW-HOW



The thousands of coke ovens built with brick supplied by GREFCO during the past 50 years have resulted in a wealth of hard-won know-how. GREFCO has molded this vast experience into the best refractories you can buy for coke oven construction.

GREFCO has continually improved the quality of silica and fireclay brick and special shapes used in coke ovens. New manufacturing techniques result in brick with lower porosity and higher density, accurately sized, to provide improved operating efficiency. When you think of coke ovens call on GREFCO for the best available refractories.

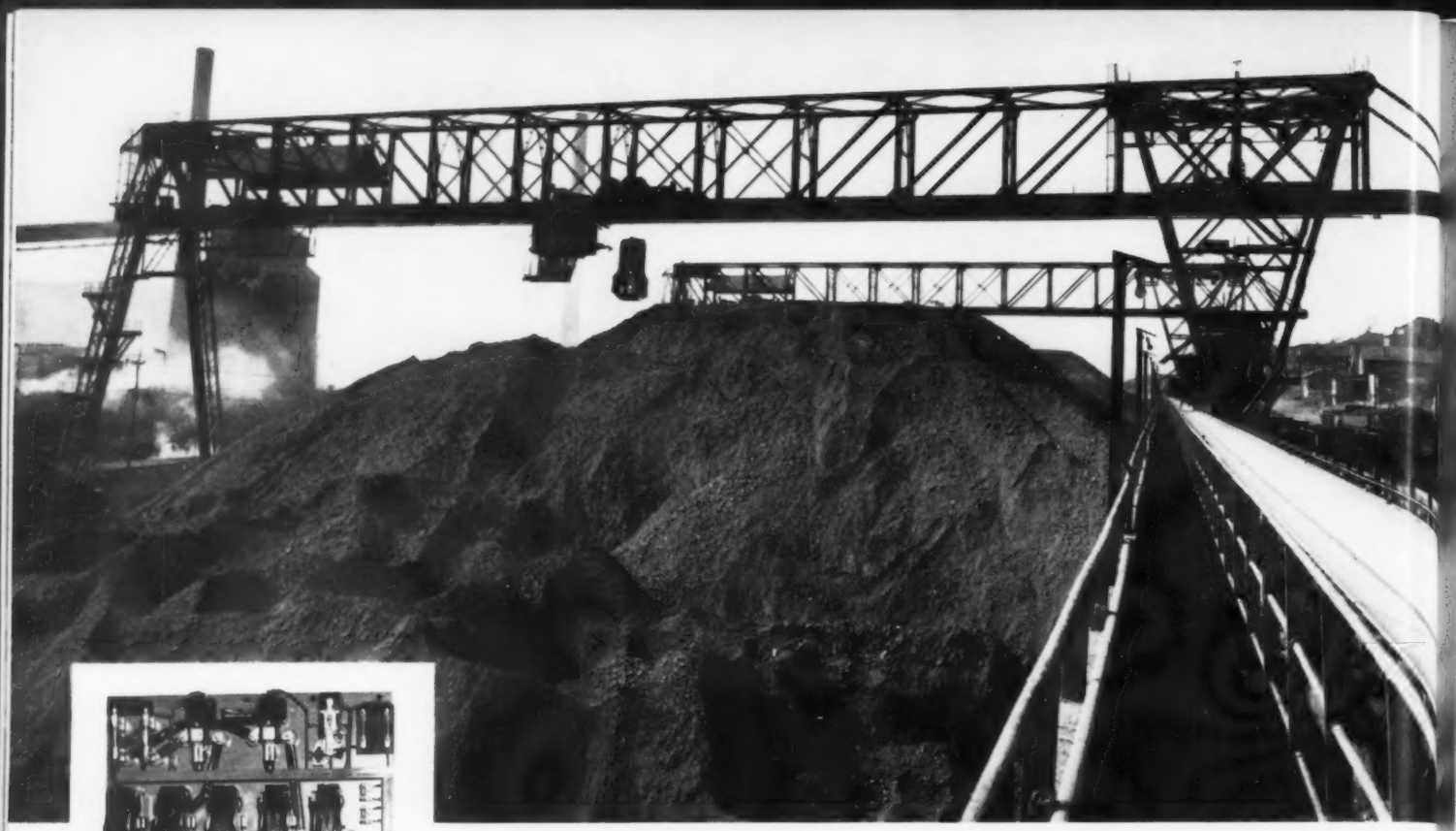
Superior brick builds superior coke ovens. GREFCO research . . . the most progressive in the industry . . . assures it. GREFCO capacity to manufacture and deliver . . . on time delivery of high quality products . . . assures it. GREFCO quality control and inspection . . . the most exhaustive in the industry . . . insures it. Satisfied customers . . . numbering into the hundreds . . . prove it.

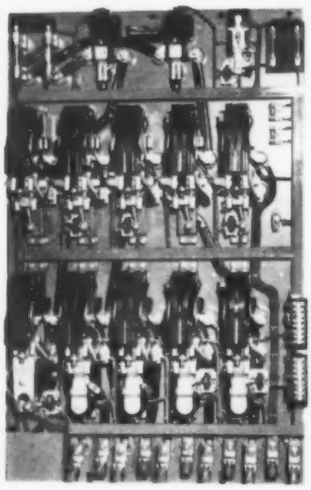
GENERAL REFRACTORIES COMPANY

1520 Locust Street, Philadelphia 2, Pennsylvania

DISTRICT OFFICES IN ALL PRINCIPAL CITIES

50th Anniversary
1911-1961





New smaller Cutler-Hammer Bul. 14115 hoist panel featuring front-wired steel panel construction with new unitized Dc contactors, factory wired to easily accessible terminals, and new panel arrangement with all protective devices at the top.

What's new in control for mill cranes?

New Cutler-Hammer Dc crane control with smaller steel panel construction

Here's the smallest area panel on the market today—made possible by Cutler-Hammer's new, unitized Dc contactors. Front wired steel panel construction provides the ultimate in space savings and ease of maintenance. No access to rear of panel is required —all devices are front removable.

New unitized contactors in six sizes (25, 50, 100, 150, 300, 600 amperes) are surface mounted or elevated with spacers for most efficient utilization of panel space. Epoxy resin impregnated coils are completely protected against moisture and dust. Improved blow-out structure increases contact life. Predrilled mounting holes on insulated steel unit bases accommodate interlock assemblies with field convertible contacts.

Check the simple circuitry of the Cutler-Hammer Bulletin 14111 and 14115 crane control. It provides the ultimate in performance with a minimum number of components.

What's New at Cutler-Hammer?

There are many more new and improved products in Cutler-Hammer heavy duty mill control equipment, including the most complete line of mill duty brakes and crane safety limit stops up to 375 hp. For complete details on circuit, mechanical and electrical features, write for Pub. No. LJ-76-S232. Better yet, call your local Cutler-Hammer sales office and ask for a personal rundown on new developments that will improve your crane control.

WHAT'S NEW? ASK...

CUTLER-HAMMER

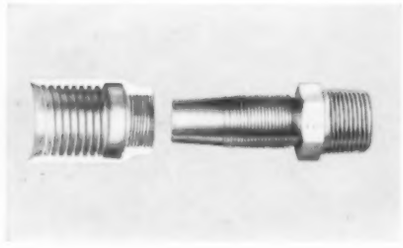
Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

Save Hose Replacement Dollars

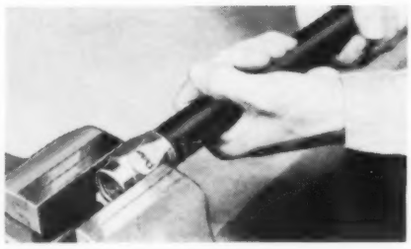
Using PARKER Fittings with PARKER Hose to make Replacement Assemblies Faster

Installing Parker "Hoze-lok®" Fittings on Parker "No-Skive" Hose . . . NO SKIVING!

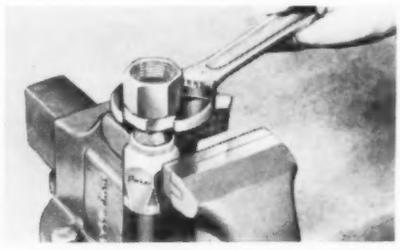
Installing ordinary fittings on ordinary rubber-covered hose . . . First, this messy skiving job.



Design of the "Hoze-lok" socket (left) makes the difference. The deep-tapped threads accept the **controlled thickness** rubber cover of Parker "No-Skive" Hose as they plow their way down to the wire braid of the hose. The rubber is displaced, not removed.



Just screw the hose in counter-clockwise, by hand. The rubber cover fills completely the space between each thread. It both protects and cushions the wire braid, eliminating a major cause of hose failure. A little Parker "Threadlube" is needed here.



The nipple, which is also the hose end fitting, screws in last, clockwise, in the usual way. You are now ready to make up the other end of your Parker No-Skive Hose Assembly. This method is not only faster; it gives you a better assembly. See next page.

You can install a Parker "Hoze-lok" Fitting on small-diameter Parker "No-Skive" Hose in 60 seconds. On 3/4" Parker hose, it takes 2 minutes or less. On very large sizes, allow 5 minutes per fitting. Hose replacement time is reduced to minutes the Parker No-Skive Way!

..*the* Parker No-Skive Way

Why Parker No-Skive Hose Assemblies Last Longer

BETTER PROTECTION FOR THE HOSE AT ITS POINT OF GREATEST STRESS

Most hose failures result from flexing. Ordinary hose, skived to the bare wire at the critical point where the first thread of the hose fitting bears directly on the wire braid, fails right there. As our picture shows, the leading thread of Parker "Hoze-lok" Fittings cannot reach the wire. The cushioning effect of the compressed rubber between the threads reduces the stress concentration at this point. Gripping by direct contact between the deep-tapped "Hoze-lok" threads and the wire braid occurs well within the fitting, where no flexing occurs.

Actual tests prove the effectiveness of this better design feature. Parker "Hoze-lok" assemblies on Parker "No-Skive" Hose rarely fail at the fitting, even when stressed to the burst point.

HOW PARKER DEVELOPED A BETTER HOSE TO MAKE THESE SAVINGS POSSIBLE

Parker "Hoze-lok" Fittings can be used with any hose, but you still have to skive ordinary rubber-covered hose, even with "Hoze-lok" fittings. Parker "No-Skive" Hose, however, is made to rigid specifications that limit and *control* the thickness of the cover to the exact amount of rubber that the corresponding size of "Hoze-lok" fitting will accept, when attached without skiving.

In all other characteristics, from the inner liner to the OD of the outermost wire braid, Parker "No-Skive" Hose conforms to S.A.E. specifications. In addition, because only a better grade of rubber compound can be extruded to Parker's exacting *controlled thickness* specification, the increased resistance to abrasion of the Parker "No-Skive" rubber cover results in a better hose.

PARKER HANNIFIN CORPORATION

ARRANGE NOW FOR A PARKER NO-SKIVE DEMONSTRATION IN YOUR OWN PLANT OR OFFICE

3079-PH

Parker FITTINGS AND HOSE DIVISION

17325 Euclid Avenue • Cleveland 12, Ohio

PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

Gentlemen: We would like to see the Parker No-Skive Way to make up replacement hose assemblies demonstrated, without any obligation on our part, of course.

Please ask your salesman or nearest "Hoze-lok" distributor to get in touch with me:

Name_____

Title, Department or Division _____

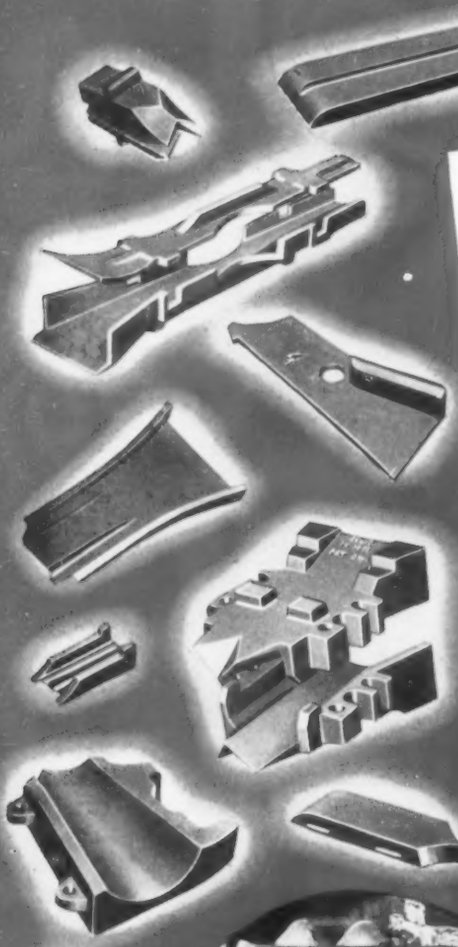
Company_____

Address_____

City_____ Zone_____ State_____

We use hose for_____

TRANTINYL GUIDES
THE STEEL INDUSTRY



Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES

Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.

12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

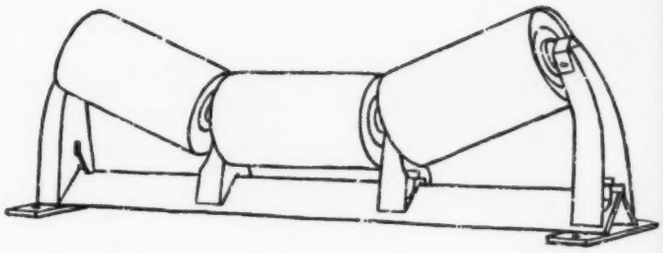
Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape

Youngstown Alloy Casting Corporation
Youngstown, Ohio

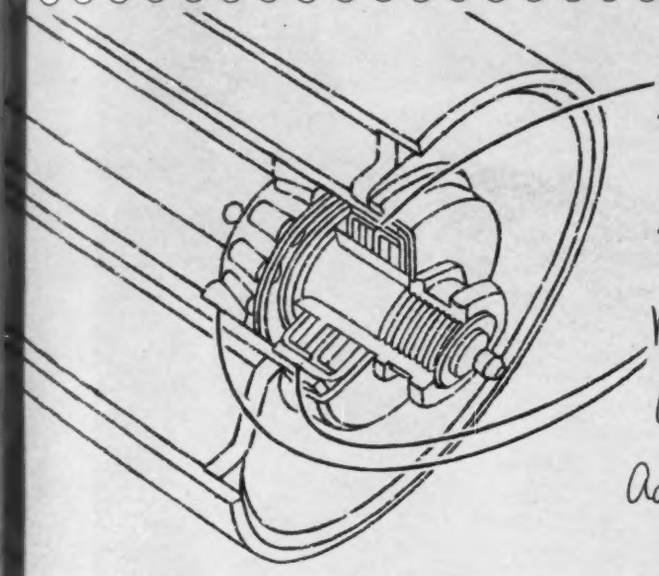
Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

A design engineer notes

how Link-Belt idlers



trim belt conveyor maintenance costs



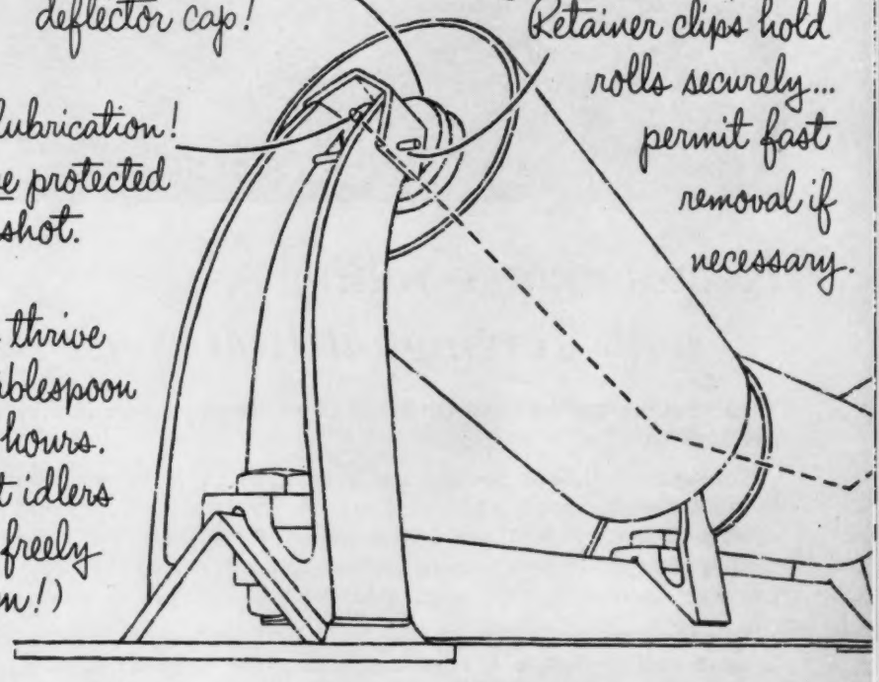
A Link-Belt Exclusive! Cartridge seal protects bearings three ways... a laminated felt-neoprene contact member... a multi-labyrinth... and grease filled clearances. Grease stays in! Dirt stays out!

Machined "seats" for bearings and seals assure perfect alignment in heavy-gauge center tube.

Added protection... deflector cap!

Easy to remove rolls! Retainer clips hold rolls securely... permit fast removal if necessary.

Grease-through lubrication! Fast, through one protected fitting, with one shot.



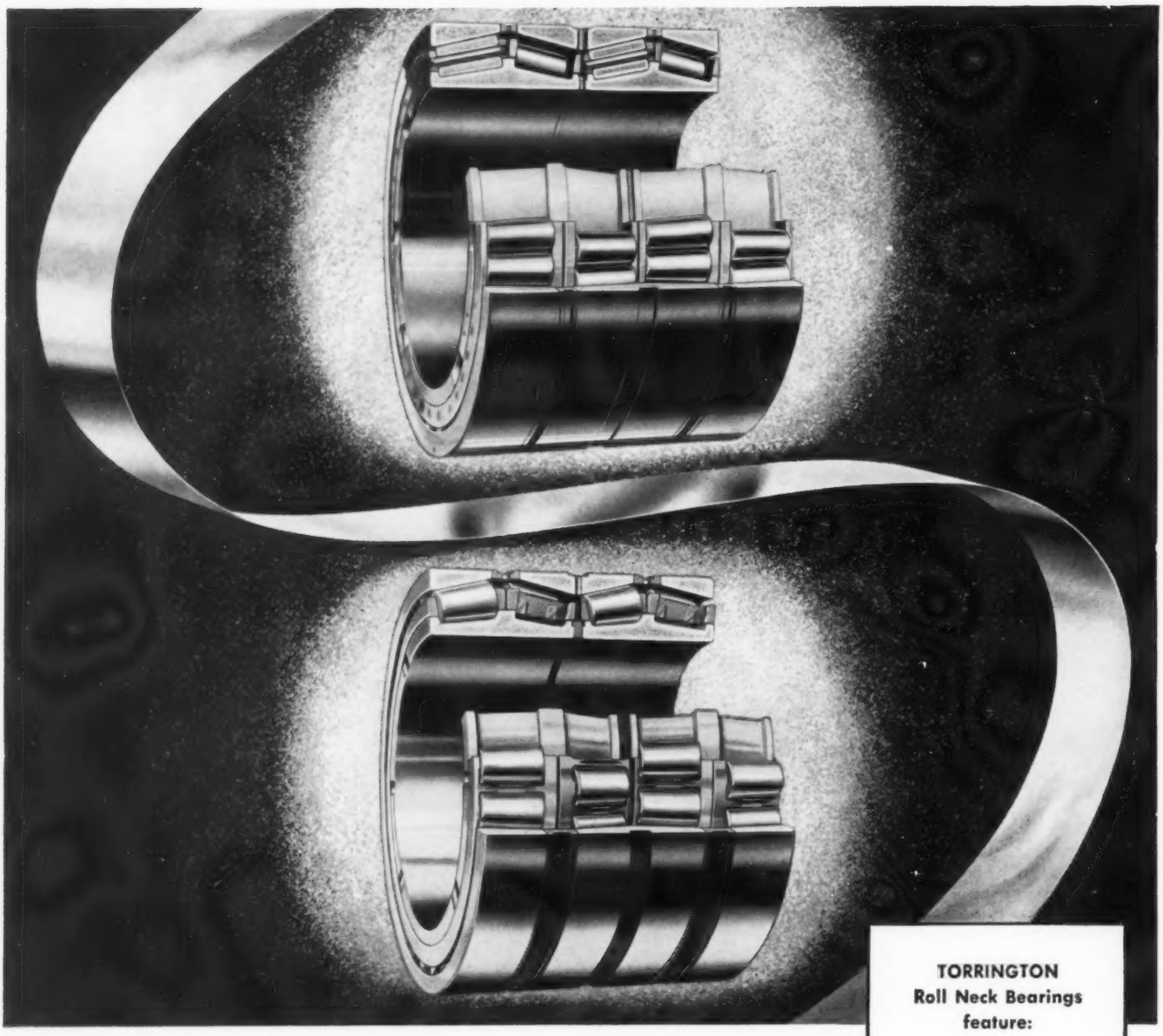
Important! Link-Belt idlers thrive on very little grease. Just one tablespoon per roll every 4,000 operating hours. (In a test installation Link-Belt idlers were still operating quietly and freely after 36,000 hours of operation!)

Low-cost maintenance! Fewer replacements! Longer belt life! You realize all three benefits when you choose Link-Belt idlers . . . *industry's broadest* line. "Pin-point" selection to suit the service. Many types and sizes, roller bearing and ball bearing, for light, medium, heavy-duty service, 20°, 35°, 45° types. For full details, contact your nearest Link-Belt office or authorized stock-carrying distributor. Look under CONVEYORS in the yellow pages of your telephone directory. Ask for Belt Conveyor Idler Book 2816.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,729



Keep tonnage rolling... with Torrington Roll Neck Bearings

Tonnage rolled per turn and downtime saved—these measure bearing performance in metal rolling mills.

Torrington Roll Neck Bearings are designed for top performance under tough conditions. Maximum capacity and exceptional life expectancy are combined in bearings that operate efficiently under the severest thrust and radial loads. Torrington's advanced heat treating of carburizing-grade steels provides optimum resistance to wear and shock loads. Lubricant grooves on cone faces minimize roll neck galling under creep conditions.

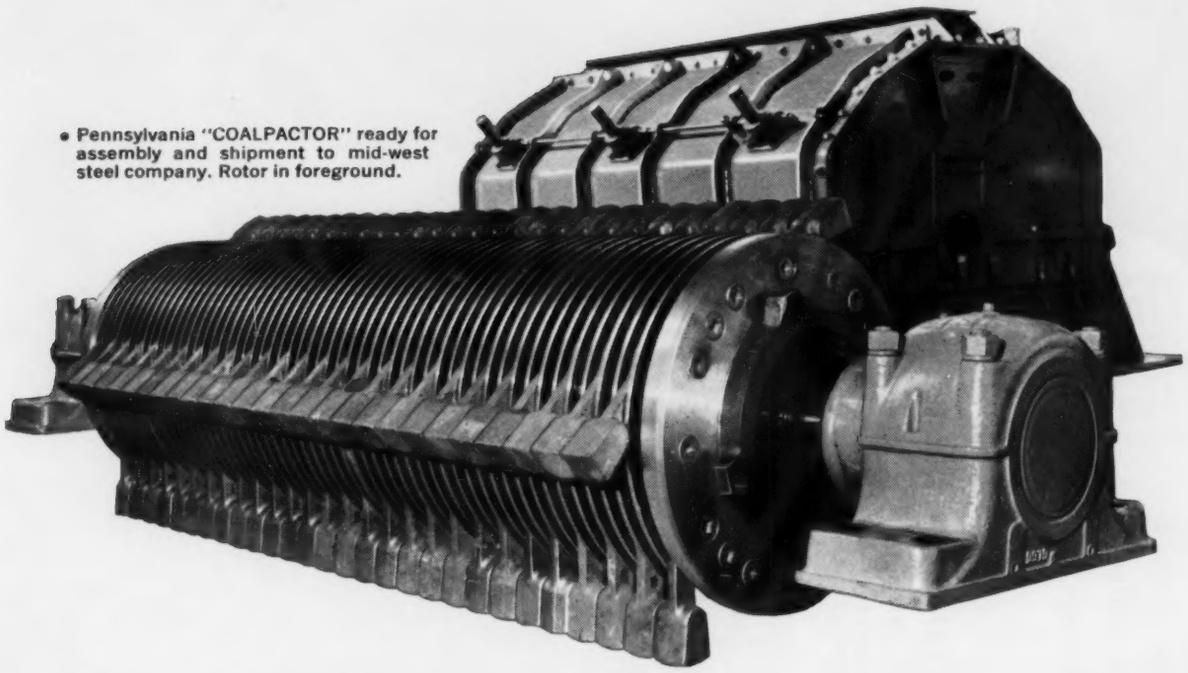
When you choose Torrington Roll Neck Bearings you can be sure they will pay off in more steel production at lower cost. More than a quarter century of experience in anti-friction bearing engineering for metal rolling mills—makes Torrington quality a byword in the industry.

TORRINGTON Roll Neck Bearings feature:

- carburizing grade alloy steels
- advanced heat treatment
- minimum cross section
- high radial and thrust capacity
- resistance to shock loads
- precision manufacture
- grooved cone faces

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.



• Pennsylvania "COALPACTOR" ready for assembly and shipment to mid-west steel company. Rotor in foreground.

NEW PENNSYLVANIA "COALPACTORS"®

offer 8 advantages in preparing most coking coals

1. Lower initial capital investment
2. Maintains rated capacity under high moisture conditions
3. Pulverization levels equal to or better than conventional hammermills
4. Lower installed motor H. P.
5. Lower maintenance
6. Lower "bug dust" at equal or higher pulverization levels
7. Complete adjustability for maintaining uniform grind
8. Complete accessibility

Based on broad experience with hundreds of coke plant installations of Pennsylvania Impactors and Hammermills, Pennsylvania has now designed the new "COALPACTOR" incorporating the most desirable features of each . . . and planned specifically for preparation of coal for by-product coke plants.

Thorough laboratory and field tests have so convincingly proved the "COALPACTORS" advantages that already many units have been installed in major plants. More are on order.

Check over the 8 "COALPACTOR" advantages listed at left. If these interest you, we'd be glad to tell you more. Just write and ask for the full story on "COALPACTORS"—including specific results of coal pulverization field tests under typical conditions. Or a Pennsylvania field engineer would be glad to call if you wish, and discuss your coal preparation problems.

PENNSYLVANIA CRUSHER DIVISION

BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

★ ★ ★

Over 50 years' concentrated experience in all types of material reduction. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

"COALPACTOR" is a registered trademark of Pennsylvania Crusher Division.

PENNSYLVANIA CRUSHERS

BATH-BUILT

VICTOR R. BROWNING
MILL TYPE CRANES
to Specification..

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

ASEA

builds world's largest load rated cell... 7 million pounds

Rated at 7,000.000 pounds, the largest capacity Pressductor, now being built in Sweden for a U. S. steel mill, measures 25″x24″...and is only 3″ thick. Its output voltage is sufficient to drive an instrument or relay with no need for amplifier.

ASEA Pressductor's error of measurement, under normal conditions, is within ±1% of actual value between 10-100% nominal load. Under ideal conditions, even better accuracies may be obtained.

In service at many modern rolling mills, ASEA Pressductors are proving their suitability for the most difficult applications where dirt, dust and moisture problems exist. ASEA Pressductors withstand considerable overload without damage...are free of hysteresis (particularly important in automatic system regulation) .. resist lateral forces...offer interchangeability of units (no recalibration necessary)...and both calibration and performance are unaffected by age.

The superiority of ASEA Pressductors is now being proved in the following applications:

Measurement of:
rolling forces and strip tension in rolling mills ■ propulsion forces in ships ■ web tension in paper machines ■ column pressures in buildings

Weighing of:
coils in rolling mills ■ ore, etc., in hoppers ■ loads on cranes, hoists, elevators ■ charges in electric furnaces

Overload protection:
for transportation and handling equipment

Future planned applications include:
Measurement of:
rocket test stand thrust ■ tension of conveyor belts ■ torque in sluice gate hoists ■ pull in carrying cables and drag lines ■ drilling pressures for deep drilling

Weighing of:
trucks, railway cars, aircraft, etc., on loading platforms

Write for detailed descriptions of ASEA Pressductors and the advantages they offer to your specific job application.

U. S. Sales and Service: ASEA ELECTRIC, INC.
East Coast: 500 Fifth Avenue, New York 36, N. Y.
West Coast: 55 New Montgomery Street, San Francisco 5, California

"ASEA world pioneer in electrical products for industry"

SPRAYING SYSTEMS CO.

DESCALING NOZZLES

in hardened stainless steel

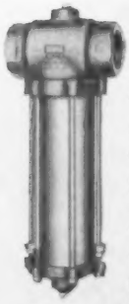
compact
modern design . . . only ½ to ⅓ the size of old nozzle types

in stainless steel with tungsten carbide orifice tips

advanced hydraulic design
gives extremely sharp, hard hitting FLAT SPRAY pattern

large open orifice
keeps clogging to a minimum

Here are spray nozzles with sharp, high-impact flat spray patterns to materially improve your descaling operations. They're small in size for easier installation and better performance. The unusually large orifices go far in solving clogging problems. Made in all capacities in hardened stainless steel for high resistance to sand and silt. And for maximum possible abrasion resistance, they're also made with Tungsten Carbide orifice inserts. Just write . . . we'll be happy to send you complete Descaling Spray Nozzle information.



HEAVY DUTY LINE STRAINERS

Spraying Systems now offers line strainers in a full range of sizes . . . with threaded connections up to 4" N.P.T. size . . . and flanged connections in 3", 4" and 6" pipe size. Designed for operation at pressures up to 125 psi. Unusually large screen areas for high volume capacity. Heavy duty, reinforced screens. Easily flush-cleaned through bottom plug or drain cock. Write for Bulletin 94.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

HODSON SPINDLE AND COUPLING BOX COMPOUND

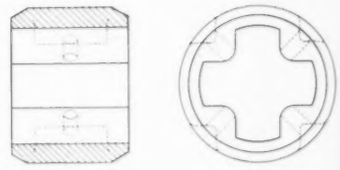
Maintenance Costs Reduced

Stop Spindle and Coupling Wear by using
HODSON #4025 SPINDLE AND COUPLING BOX COMPOUND

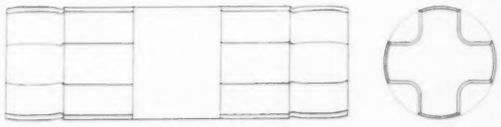
A tough, resilient, E.P. (extreme pressure)
Compound for Mill - Lead - or Pinion Spindles

1. - Labor and material costs but a few dollars per week per spindle application.
2. - May be pumped to pods without disassembling equipment.
3. - A full schedule of turns per application with no down time.
4. - Roll changes easy and clear - no throw-off.

Typical Mill Coupling



Typical Mill Spindle



HODSON #4025 SPINDLE AND COUPLING BOX COMPOUND specifically designed and test proven eliminates wear, noise, and of course, backlash.

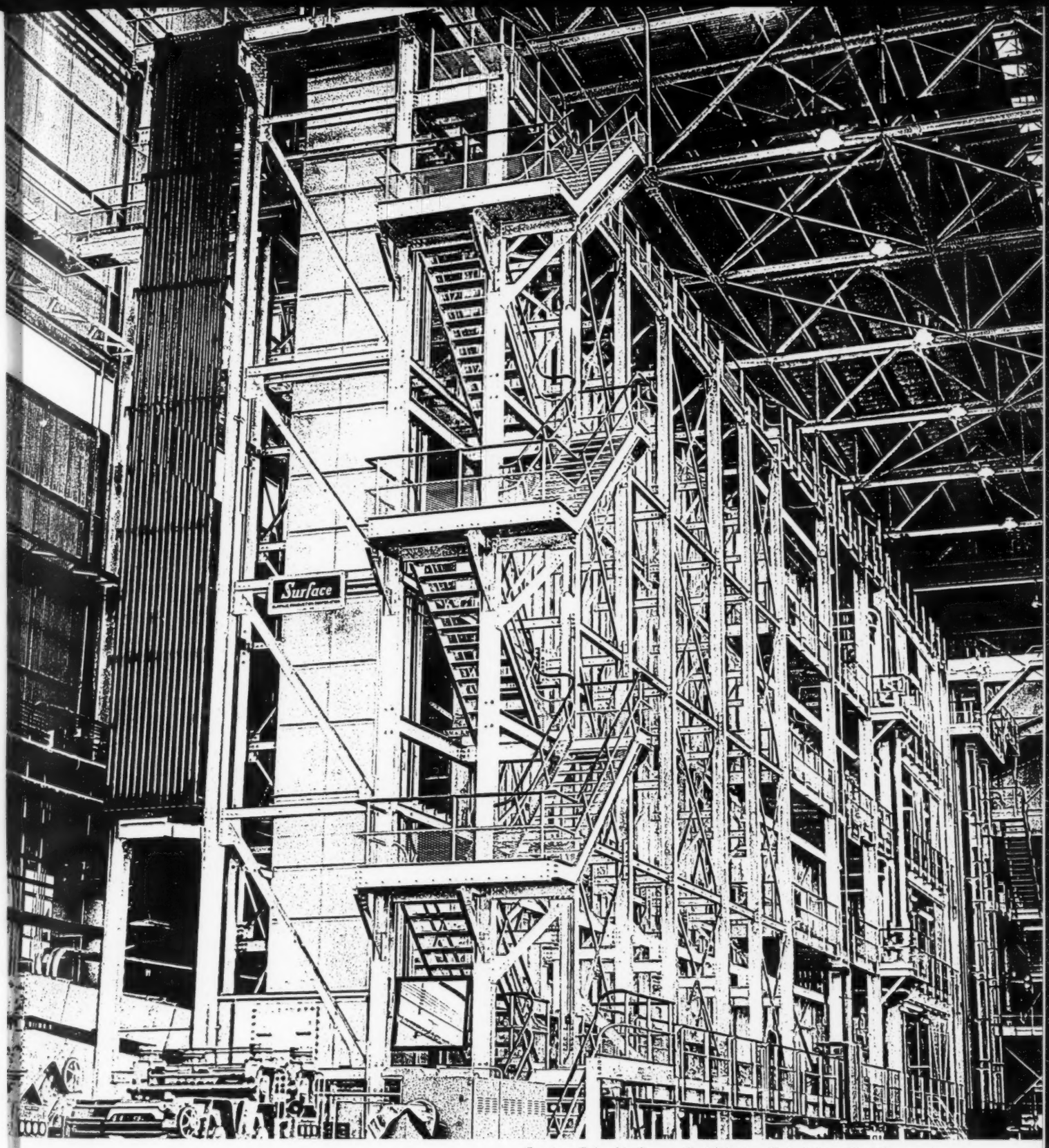
HODSON #4025 SPINDLE AND COUPLING BOX COMPOUND may be swabbed or pumped directly to the spindle and coupling boxes during mill changes.

CASE HISTORY

A 24" Cross Country Mill - 18" Spindles, shows savings of several hundred dollars per annum in replacement and rebuilding or reclaiming of spindles and couplings.

Demonstration of suitability of material, or trial sample if desired, upon request.

THE HODSON CORPORATION
5301 West 66th Street
Chicago 38, Illinois

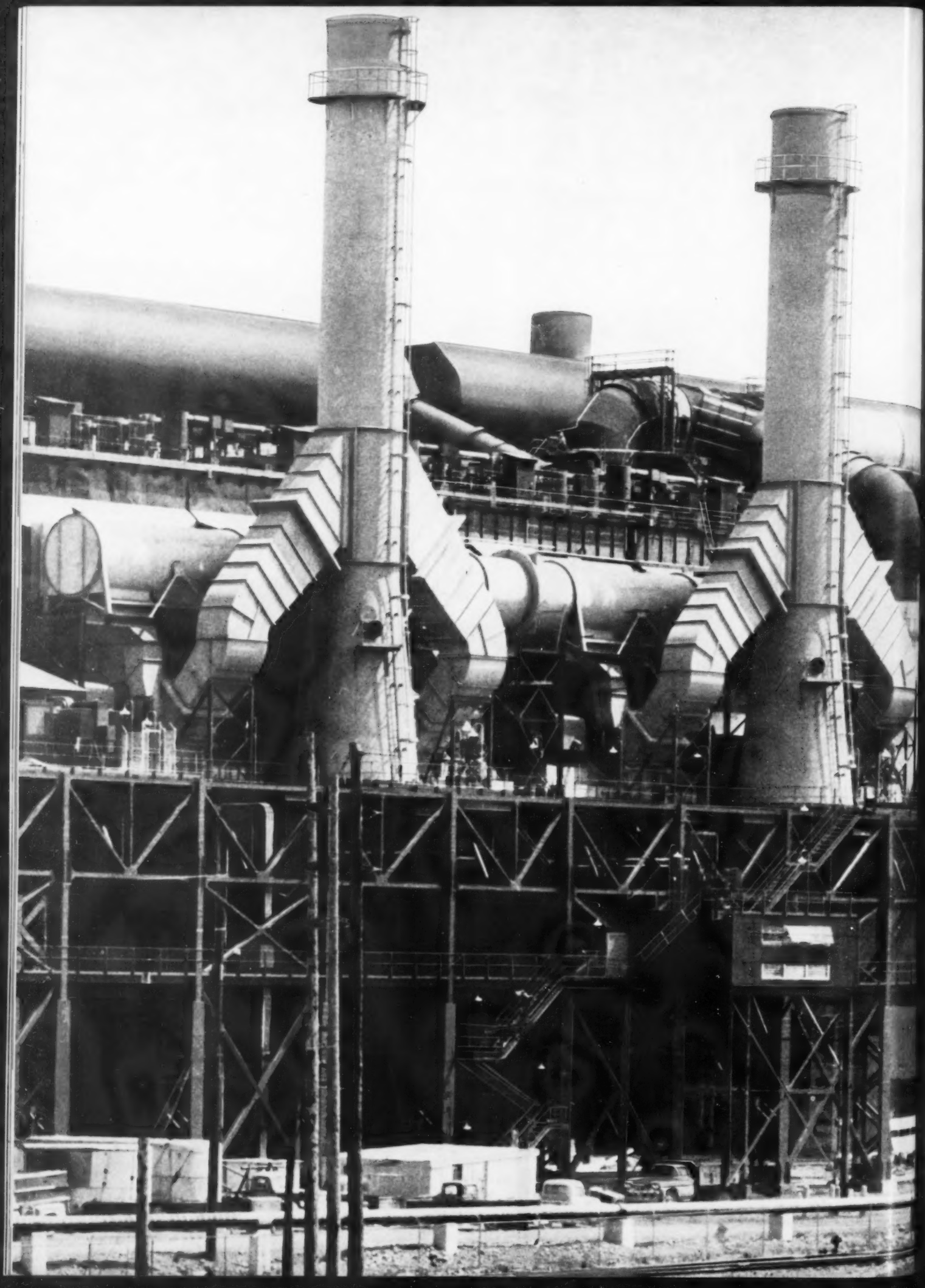


Courtesy Columbia-Geneva Steel Division, United States Steel Corporation

Sign of performance better than specified: The modern tin plate industry demands highest quality at lowest operating cost—requirements which can be met only with continuous annealing, a process pioneered by Surface. This Surface installation produces 96,000 lbs/hr of .010″ strip at speeds up to 1500 fpm. Address inquiries to 2404 Dorr Street, Toledo, Ohio.

SURFACE

SURFACE COMBUSTION, Toledo 1, Ohio/ a division of Midland-Ross Corporation



Oxygen-lance smoke eliminated at J&L Cleveland!

Western Precipitation's experience and "know-how" has solved one of the major problems resulting from the new high production oxygen steel making process—the billowing ore-laden red smoke from open hearths and converters.

The J&L system is a complete turnkey job, handled by WP from preliminary studies, through engineering, construction, and erection to operation. WP-Joy equipment integrated in the package includes electrostatic precipitators, complete flue work, Joy Rotating Diffuser fans, dust handling units, waste-heat boilers, and a complete control system. Total gas flow is approximately one million CFM.

This is another example of complete gas cleaning service to the steel industry by Western Precipitation, the leader in the field—with more successful installations than any other organization.

If you have a dust control problem, WP can solve it. For more information, or an answer to your particular problem, write Western Precipitation Division, Joy Manufacturing Company, 432 Oliver Building, Pittsburgh 22, Pa. (In Canada, write Precipco, 8285 Mountain Sights Ave., Montreal, P.Q.)

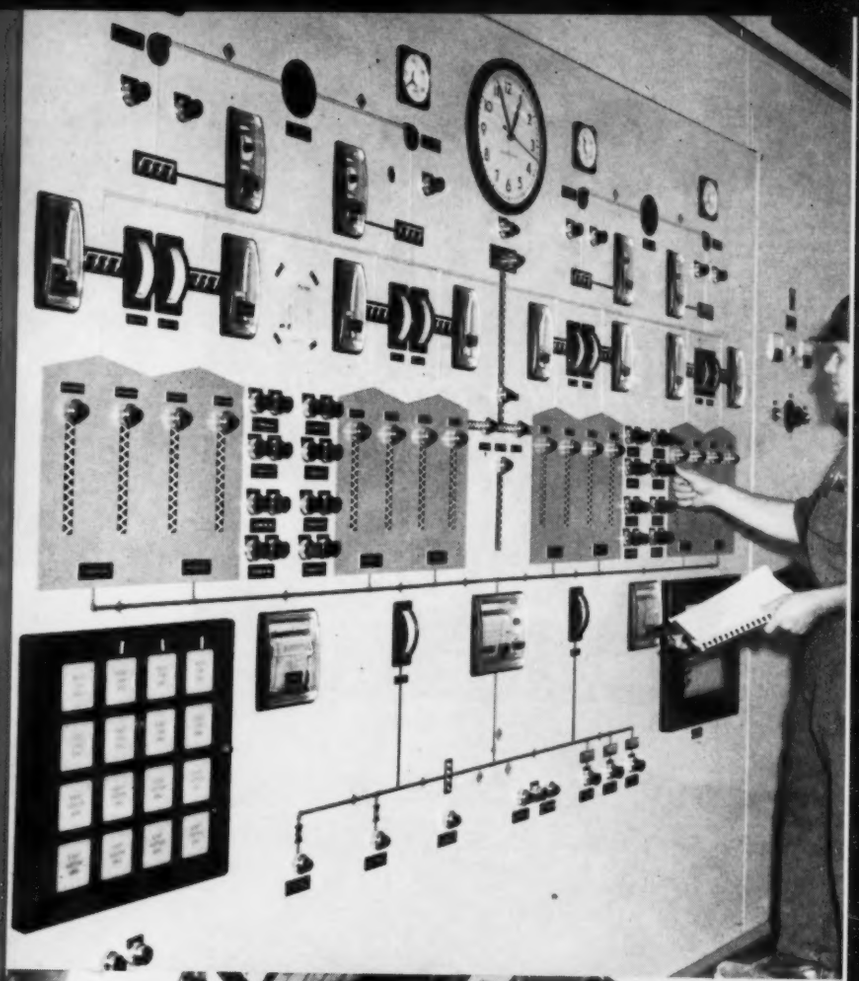
Dust and fume control since 1907

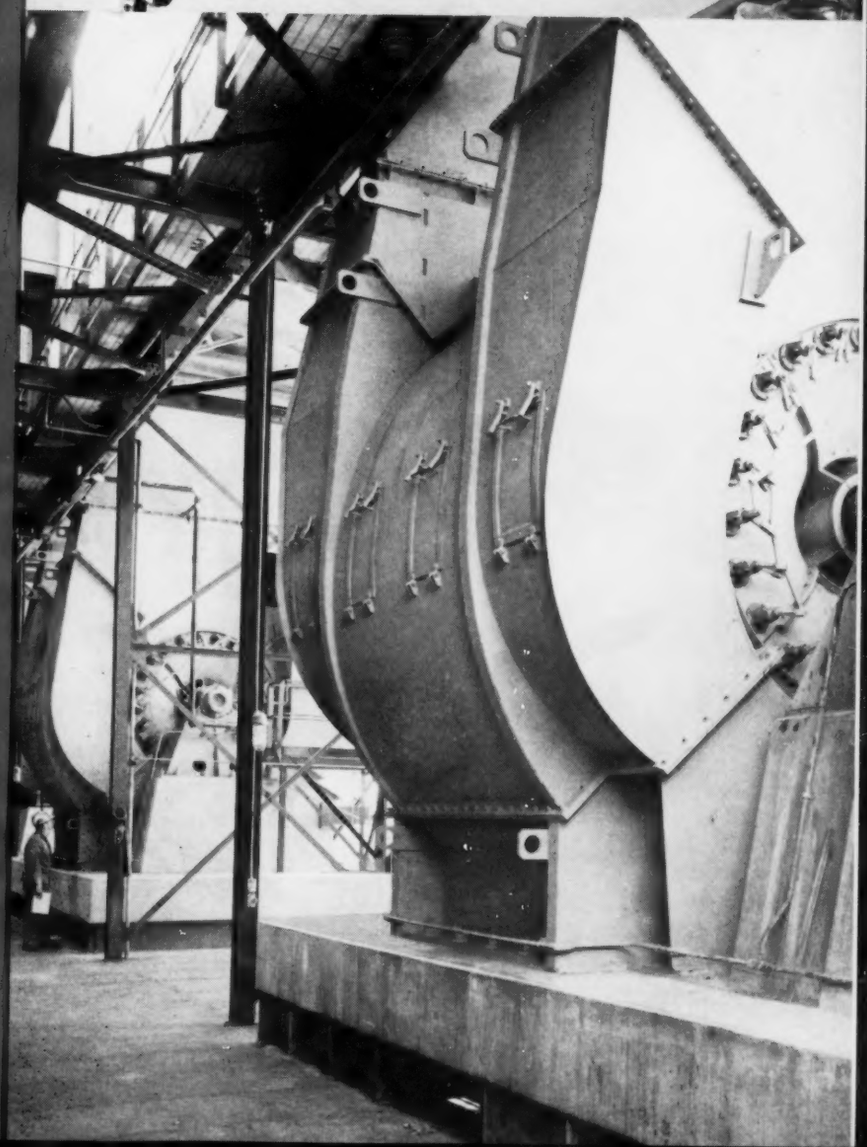
WESTERN PRECIPITATION

Los Angeles 54 • New York 7 • Chicago 2 • Pittsburgh 22 • Atlanta 5 • San Francisco 4

Division of Joy Manufacturing Company

ELECTROSTATIC Precipitators
MULTICLONE Collectors
CMP Combination Units
DUALAIRE Jet-Cleaned Filters
THERM-O-FLEX Hi Temp Filters
TURBULAIRE Scrubbers
JOY-MICRODYNE Scrubbers
also: **HOLO-FLITE** Processors
HI-TURBIANT Heaters
TURBULEX Processers





WP precipitator installation (left) towers 15 stories above J&L-Cleveland.

Control console (top right), a marvel of automation, enables one man to control the entire system from one point.

Joy Rotating Diffuser Fans (bottom right), part of the turnkey design by WP.

HUNT

Air and Hydraulic

CONTROL VALVES

Whatever the application . . . whatever the service . . . whatever the pressure range . . . whatever the size . . . whatever the actuation required . . . chances are you'll find a valve in the Hunt line *exactly* suited to your needs.

Sizes range from ⅛ through 8 in. for vacuum to 300 psi air and for water, soluble oil and water, or oil to 5000 psi.

Your nearby Hunt representative will be pleased to work with you. You'll find him listed in Sweet's Product Design File.

HUNT

QUICK-AS-WINK® AIR AND HYDRAULIC

VALVES

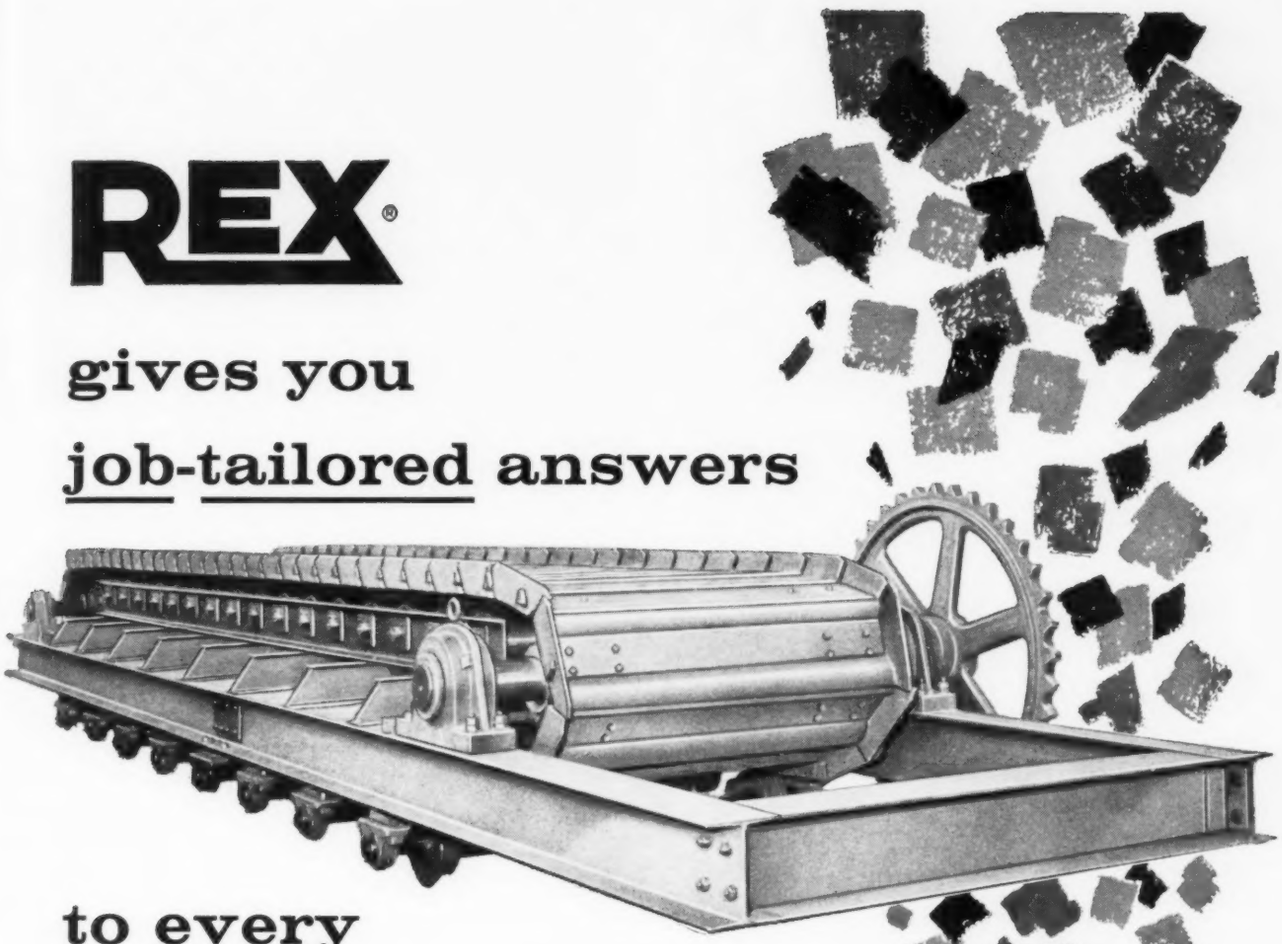
HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

For more information, write for Bulletin 603. Address Dept. ISE-961, Hunt Valve Company, Salem, Ohio.

3001

REX®

gives you job-tailored answers



to every apron feeder problem

Whatever you are feeding—broken, crushed or fine material—whatever volume or speed you require—call your CHAIN Belt Specialist. He has the experience, and the most complete line of apron feeders at his finger tips. Therefore, he is free to help you select a feeder that's tailored to meet your specific requirements. No job is too small or too large. The feeder he helps you select will give you the efficiency, economy and dependability you want.

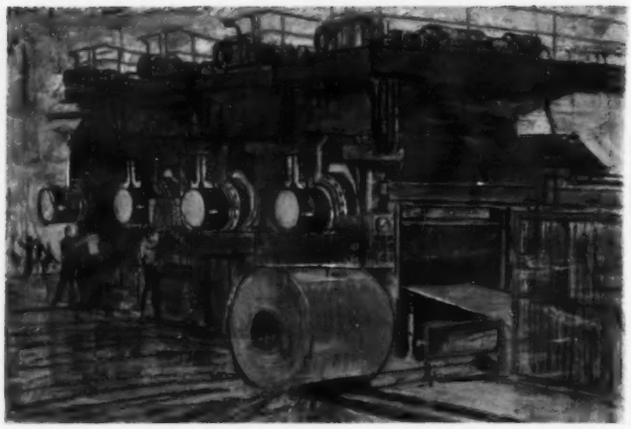
It will assure you years of accurate feeding, with savings in power, maintenance and replacement costs—and new freedom from down time.

Make sure you select a feeder tailored to your specific needs. Write CHAIN Belt Company, 4693 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: Rex Chainbelt (Canada) Ltd., Toronto and Montreal.

REX®
CHAIN BELT COMPANY

A call to CHAIN Belt adds a man to your staff, but not to your payroll.

GENERAL ELECTRIC AUTOMATION SYSTEMS provide scientific production control. Computerized order editing, production scheduling, material ordering, and dispatching are automatically integrated with production processes.



GENERAL ELECTRIC AUTOMATION SYSTEMS automatically control strip gage in tandem, single-stand, and reversing cold mills. New for tandem cold mills is automatic threading and set-up to reduce operating time and scrap losses.

Leadership in Industrial Automation

General Electric Is the One Source for Automation of

Advanced automation technology is one good reason why General Electric is your best source for complete automation, but it's not the only reason:

No other single manufacturer provides such a complete array of superior electrical system components. In fact, you can get from this single source—General Electric—every component *and* the system-engineering know-how to assure that your management decisions have a more immediate and profitable effect on product, costs, and mill utilization.

Long and close association with your industry has provided General Electric with unequalled experience in the design and manufacture of basic electrical systems for almost every metal-producing process. This relationship has also provided General Electric with a full knowledge and appreciation of your industry's processes, problems, and goals.

Industry's needs pace General Electric's progress—progress which has produced such firsts as: amplidyne-regulated power systems for reversing hot mills, automatic gage control for cold and hot strip mills, punched-card programmed reversing hot mills, "Top-Forward" main drives, and computer-controlled hot strip mills. Now, continuing progress is providing completely-automated production systems for virtually every metal-producing process. *And General Electric can link these processes into an over-all system of integrated automation for centralized control of your whole business.*

GENERAL ELECTRIC AUTOMATION SYSTEMS reduce mill equipment abuse. In reversing hot, hot strip, billet, structural, and bar mills, rolling dimensions are consistently held within desired tolerances.

GENERAL ELECTRIC AUTOMATION SYSTEMS protect high value of your product during shearing and classifying, side trim, and recoil line operations. Automatic inspection increases classifying speed and utilization of end product.

Your Entire Plant

For full details on General Electric's plan for complete automation, contact your nearest G-E Sales Engineer. He is ready to bring the unequalled system-engineering experience and product diversification found *only* at General Electric to bear on your automation needs. Meanwhile, if you'd like a complete set of these paintings, in color and suitable for framing, just write over your company letterhead to General Electric Company, Section 659–06, Schenectady 5, New York.

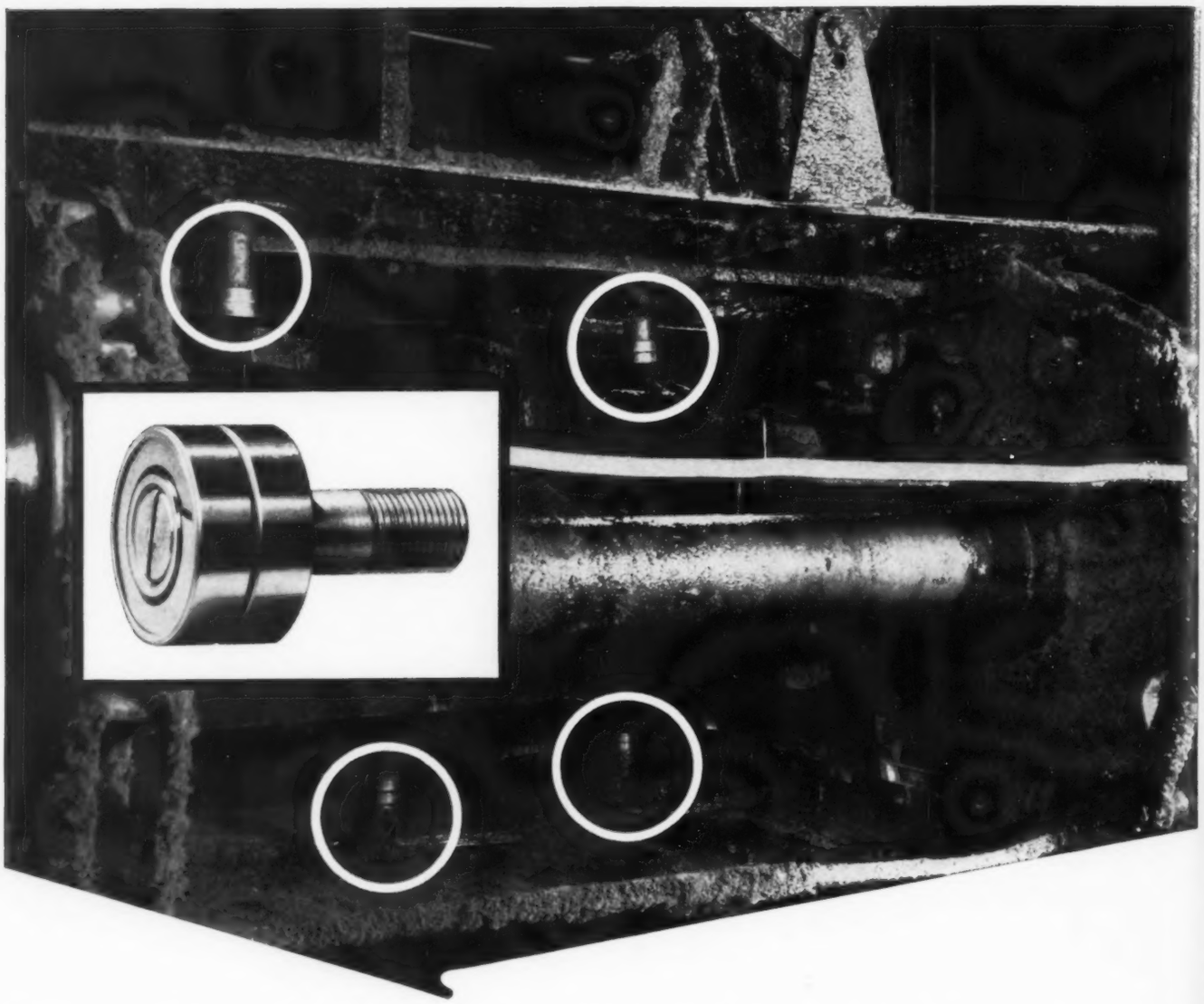
Progress Is Our Most Important Product

GENERAL ELECTRIC

GENERAL ELECTRIC AUTOMATION SYSTEMS provide maximum product consistency. Computer control and automatic sensing applied to blast furnaces, oxygen converters, sinter plants, and open hearths increase yield from given input.

GENERAL ELECTRIC AUTOMATION SYSTEMS provide discreet handling of materials in process. Automatic control of cranes, conveyors, stacking equipment and ore unloaders means precise, safe, timely handling.

GENERAL ELECTRIC AUTOMATION SYSTEMS provide more continuous operation for annealing, tinning, galvanizing, and pickling lines. Computer control assures proper conditioning of strip to customer specifications.



When thrust loads overpowered original bearings... Bearings, Inc. had the answer!

The original bearings on this automatic machine failed after a short time because they weren't designed to take the thrust loads to which they were subjected. Bearings, Inc. engineers designed and had built a special stud on which were mounted two permanently lubricated and sealed ball bearings.

To keep the cost of this design to a minimum Loctite®, a permanent bonding agent, was used to hold the bearings to the stud. This eliminated shoulders, locknuts or rings yet the bond is as strong as the best press fit.

This installation has now been in operation for many months with no failures reported.

This is not an isolated example of our services — surveys of bearing requirements, inventory control, application engineering, maintenance schedules and procedures are a regular and continuing part of our service to all customers to whom we supply replacement bearings.

Tell us how we can help YOU!

Providing bearing service in the North ➤ **BEARINGS, INC.**

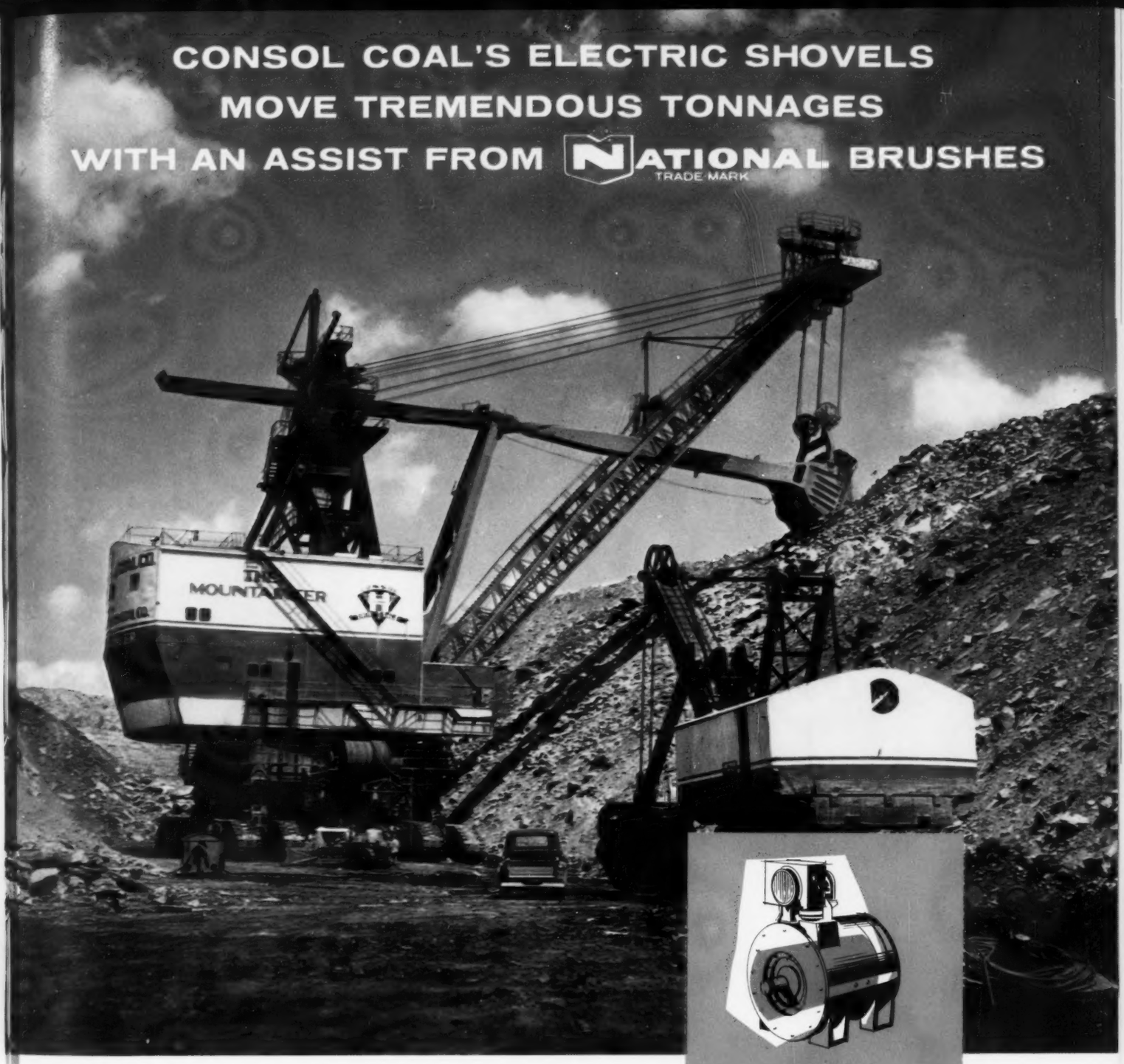
DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Fort Wayne • Indianapolis • Muncie • Terre Haute **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark • **NEW YORK:** Bolanrol Corp., Buffalo • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • Reading • York **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

and

in the South ➤ **DIXIE BEARINGS, INC.**

ARKANSAS: Little Rock • **FLORIDA:** Jacksonville • **GEORGIA:** Atlanta • Augusta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge New Orleans • **N. CAROLINA:** Asheville • Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport Knoxville • Memphis • Nashville • **VIRGINIA:** Norfolk • Richmond • Roanoke

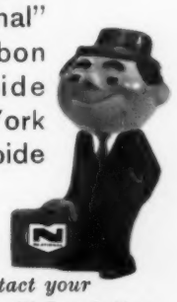
CONSOL COAL'S ELECTRIC SHOVELS MOVE TREMENDOUS TONNAGES WITH AN ASSIST FROM NATIONAL TRADE-MARK BRUSHES



Huge electric shovels take one tremendous bite after another at the eastern Ohio mines of the Hanna Coal Company, a division of Consolidation Coal Company. The swinging peak loads are extremely demanding on the shovels' electrical system–there is no room here for short cuts on quality.

"National" Brushes–small but vital components on such equipment–offer proved commutation and life under these swinging peak load conditions. A real contribution to sustained production with minimum maintenance.

National Carbon Company offers a positive service program to assist in solving any brush problems encountered today in all types of mining operations. To realize this assistance, just call your "National" Brush Man or write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. In Canada: Union Carbide Canada Limited, Toronto.

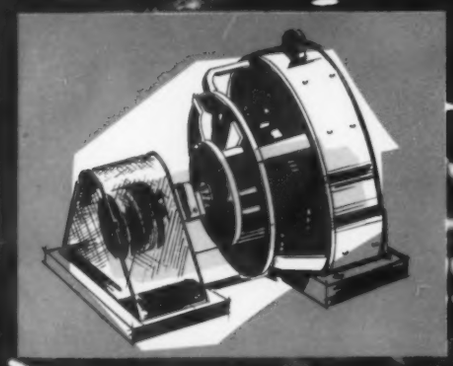


Contact your "National" Brush Man

UNION CARBIDE

"National" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY



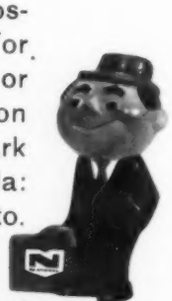
REYNOLDS METALS COMPANY KEEPS ALUMINUM PRODUCTION ROLLING WITH AN ASSIST FROM NATIONAL BRUSHES

TRADE-MARK

Reduction operations at the Corpus Christi Plant of Reynolds Metals Company produce a steady flow of basic aluminum on a round-the-clock schedule. Every component in the power plant must provide exacting performance and rugged reliability to meet production schedules.

"National" Brushes—used in the power generating section—are small but vital components that contribute to uninterrupted d.c. power supply for the aluminum pot lines. For many years these brushes have provided good commutation and life with minimum commutator maintenance.

To National Carbon Company, improved electrical operations mean a positive carbon brush service program. For details, call your "National" Brush Man or write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.



Contact your "National" Brush Man

UNION CARBIDE

"National" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY

We think this all-purpose weigh car is too good to keep to ourselves

This mark tells you a product is made of modern, dependable Steel.

Weigh anything up to 100 tons, anywhere on the track, with this new, all-purpose weigh car. It's accurate to within two-tenths of one percent of anything up to 100 tons or two separate 50-ton loads. Because the hydraulic load cells need no power, you can weigh anywhere. A weigh car can pay for itself by eliminating guesswork and human error.

At McLouth Steel Corporation in Detroit, Michigan, they cut handling time by weighing stainless steel scrap and other expensive alloying ingredients right in their stock yard. Accurate weight records give them better control of inventory and charging mixtures and make it easier to find the yield cost. Other steel producers cut costs by weighing to control electric furnace yields. We build this all-welded, stress-relieved steel car to stand up under all of these uses and give long, dependable service.

Loading scrap at McLouth Steel does double duty because the weighing is done at the same time. This cuts handling time in the mill and gives better control of the charging mixtures.

USS Weigh Cars and other industrial cars are built to last by United States Steel, a company that also uses them! We can custom design and build any type weigh car to suit your needs. Send your weight problems to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

United States Steel Corporation, Pittsburgh
Columbia-Geneva Steel, San Francisco
Tennessee Coal & Iron, Fairfield, Alabama
United States Steel Export Company

United States Steel

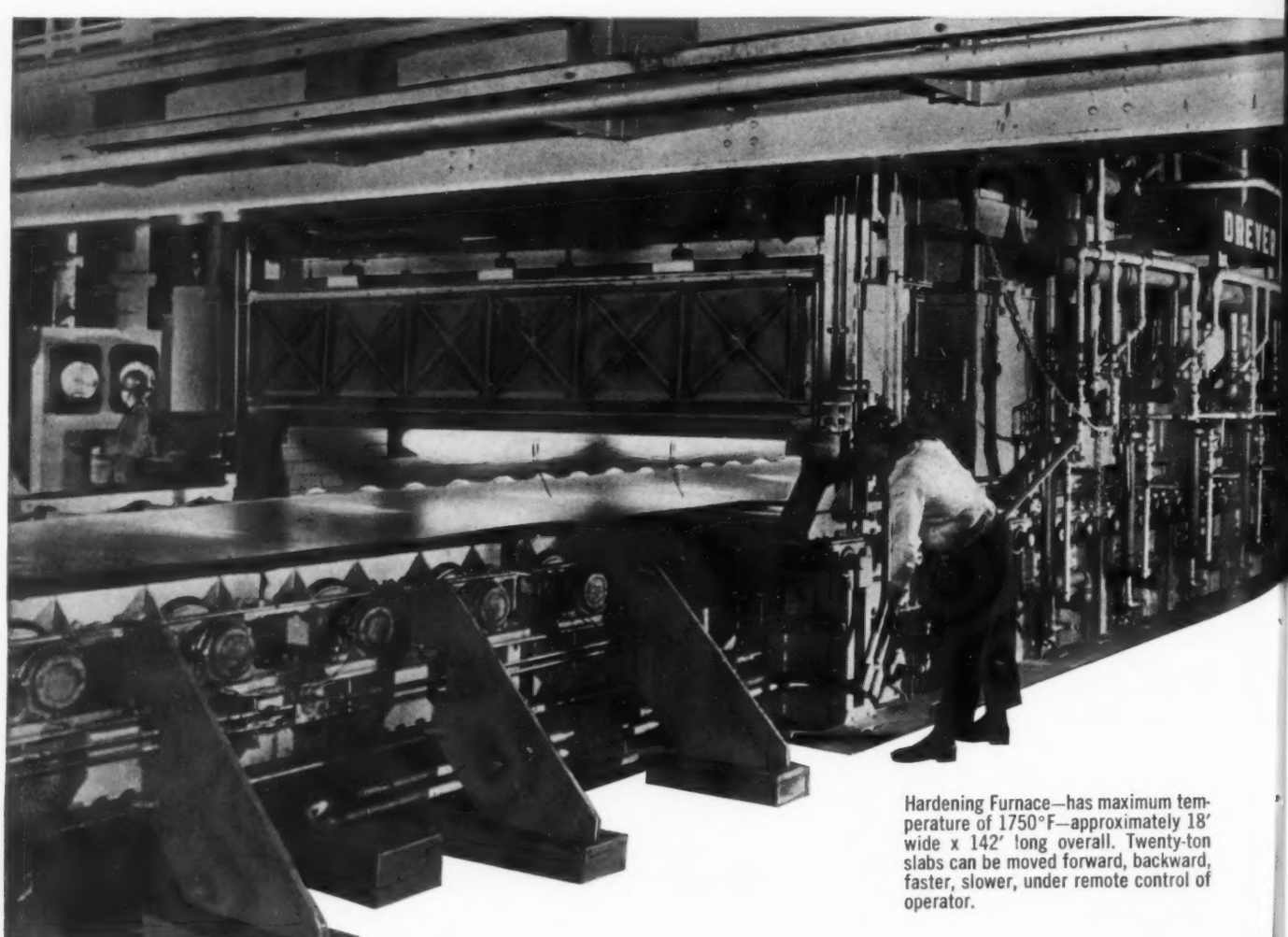
USS

TRADEMARK

NOW 4 DREVER CONTINUOUS WIDE PLATE HEAT TREATING LINES OPERATING AT U.S. STEEL'S HOMESTEAD WORKS

WITH FOUR Drever Continuous Heat Treating Lines in operation, the Homestead District Works of United States Steel Corporation has the most complete and flexible continuous heat treating plant for plate in the steel industry. The Drever Lines serve their 160″ and 100″ plate mills. Carbon, alloy and stainless plates ranging from 1/10 inch to 2 inches thick over the full hearth width, and up to 45′ long are handled in automated, prescribed operations that assure accurate, uniform treatment. Each line is operated by a single man through closed circuit television monitoring and under "pushbutton" control. The only handling required is at the charge and discharge points.

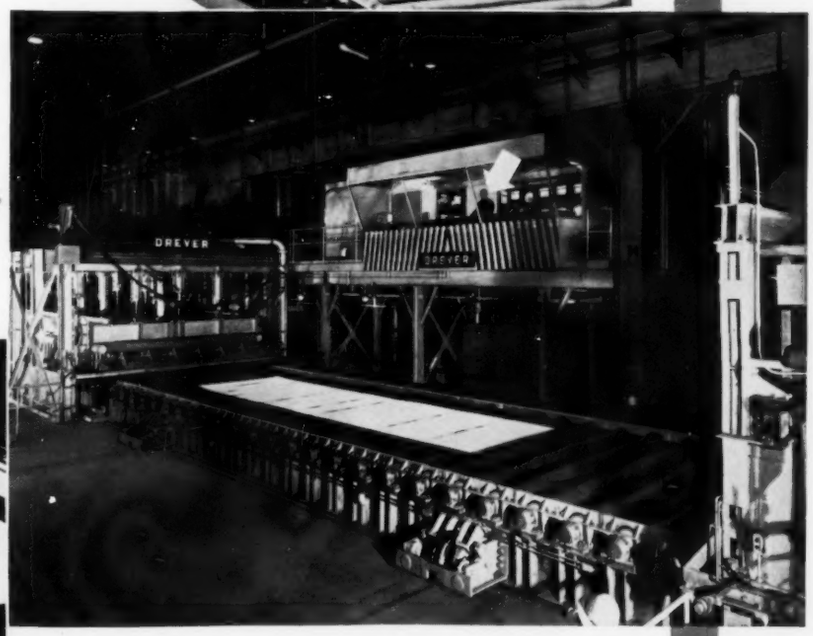
The versatility of the Drever equipment in processing wide plate for normalizing, for hardening and tempering, for annealing provides the Homestead Works with facilities for high, economical production to meet the ever growing demand for heat treated steel plate.



Hardening Furnace—has maximum temperature of 1750°F—approximately 18′ wide x 142′ long overall. Twenty-ton slabs can be moved forward, backward, faster, slower, under remote control of operator.

Original Drever Heat Treating Lines at Homestead consist of charge table, hardening furnace with pressure quench and, on left, charge table and oscillating furnace for annealing stainless steel.

Heated plate on transfer table leaving tempering furnace on right to enter pressure quench on left. One man (arrow) in control booth handles entire processing by means of "pushbutton" control.



2,500-ton pressure quench which holds plate while being flooded with 21,000 GPM of water. Except for very light gauges, plate so quenched will not require leveling.

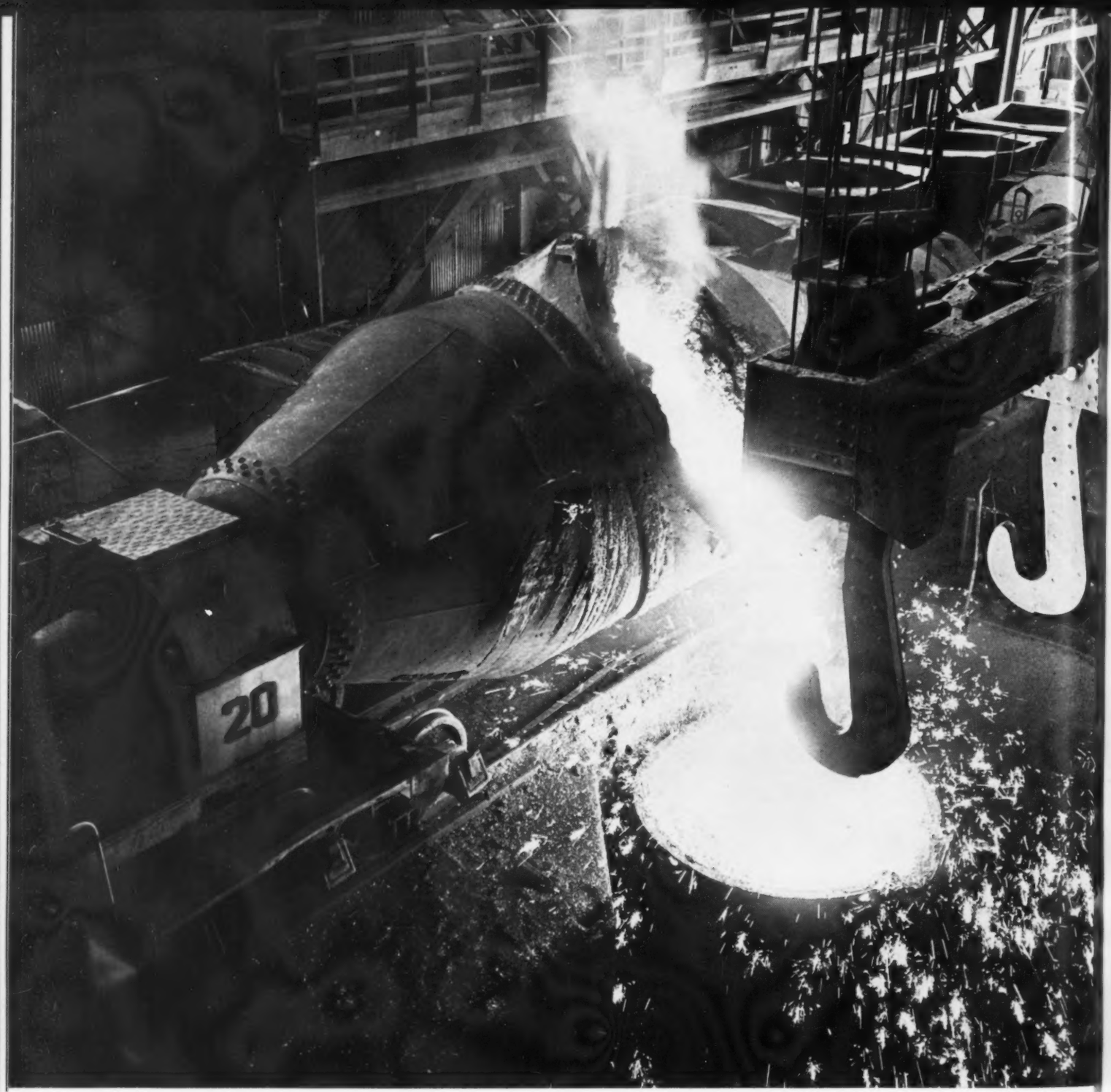
DREVER ENGINEERING FOR YOU

Drever Company has built and is engineering wide plate heat treating and strip annealing lines for steel mills across the United States and around the world. At the same time, they are producing less massive equipment for sintering, annealing, vacuum heat treating, descaling and many other metal heat treating processes. Heat Treating Specialists since 1939, they have extensive experience in all phases of metal improvement through the use of heat and atmospheres. Consult with Drever Engineers about your own process requirements. Write or phone. Drever Company, Bethayres, Pa. Wilson 7-3400.

DREVER INDUSTRIAL FURNACES

ENGINEERED TO YOUR PARTICULAR REQUIREMENTS

ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY, JAPAN AND INDIA



POLLOCK HANDLES THE "HOT STUFF"

AT GRANITE CITY STEEL COMPANY, heat after heat, day after day, Pollock hot metal cars shuttle from blast furnace to open hearth and back. Routine? Certainly! That's the way it should be. A breakdown means slowdown — or shutdown. Dependable Pollock hot metal handling equipment does the job efficiently, unobtrusively—as it was designed to do.

The Pollock Box Score at Granite City: 6-200-ton hot metal cars • 6-400-cu.-ft. slag cars • 5-320-cu.-ft. cinder cars • 7-250-ton open hearth ladles • 5-285-ton open hearth ladles

POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN, OHIO
Associated in Great Britain with Ashmore, Benson, Pease & Co.

ENGINEERS, FABRICATORS AND ERECTORS OF BLAST FURNACE STEEL WORK . . .
HOT METAL AND SLAG HANDLING EQUIPMENT FOR . . . BLAST FURNACE, OPEN HEARTH AND ELECTRIC FURNACE PLANTS

For Heavy Industry . . .

CROUSE-HINDS ARK-trol®

ELECTRICAL CONNECTORS

reduce downtime and maintenance costs!

Very little can impair the reliability of an ARK-trol Connector . . . short of malicious mischief. Even that takes some doing!

ARK-trol Connectors meet and exceed the most rigid requirements of industrial electrical codes . . . highly resistant to corrosion . . . tough enough to withstand vibrations up to 20G's, or shocks up to 50G's without impairment of performance. Temperature limits range from −65°F. to +350°F. constant. And, in addition, ARK-trol is circuit-breaking under full load.

NEMA Ratings for other environmental factors:

CLASS	DEFINITION	CONDITION
1 & 12	Industrial Use	Excludes dust, lint, fibres, flyings, oil or coolant seepage.
2	Moisture Resistant	Materials are unaffected by condensation.
3 & 3R	Raintight & Splashproof	Outdoor areas.
4	Watertight	Excludes water by hose spray or impingement.
5 & 13	Dust-Tight	Excludes dust, but performs normally if dust is accidently enclosed during disconnect.
6	Submersible	Performs normally when submerged in water.

ARK-trol Electrical Connectors are U.L. listed and conform to J.I.C. Standard.

REDUCED SIZE and WEIGHT: PLUG and RECEPTACLE			
SIZES	RATINGS	WEIGHT	DIMENSIONS
017	20-30 Amps.	16 oz.	7⅜" long x 1.630" dia.
021	20-30 Amps.	20 oz.	7⅜" long x 1.630" dia.
033	30-100 Amps.	40 oz.	9⅞" long x 2.685" dia.
041	100-200 Amps.	65 oz.	10⅜" long x 3.190" dia.

INSERT and CONTACT FEATURES

- **Interiors are reversible and interchangeable.**
- **Four alternate polarizations (5 total).**
- **Available with or without provision for grounding.**
- **Contacts are removable.**
- **Crimp, solder or pressure terminations.**
- **One to 100 contact possibilities.**
- **Contact sizes: 16, 12, 10, 4, 1/0, and 4/0.**
- **Three types of cord grip: standard, mechanical and wire mesh.**

Write for Bulletin 2711 containing complete descriptions, specifications and configuration patterns.

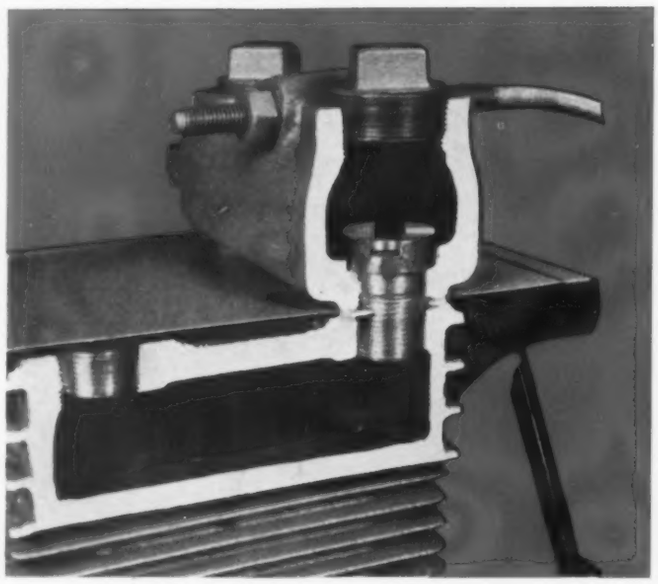
CROUSE-HINDS

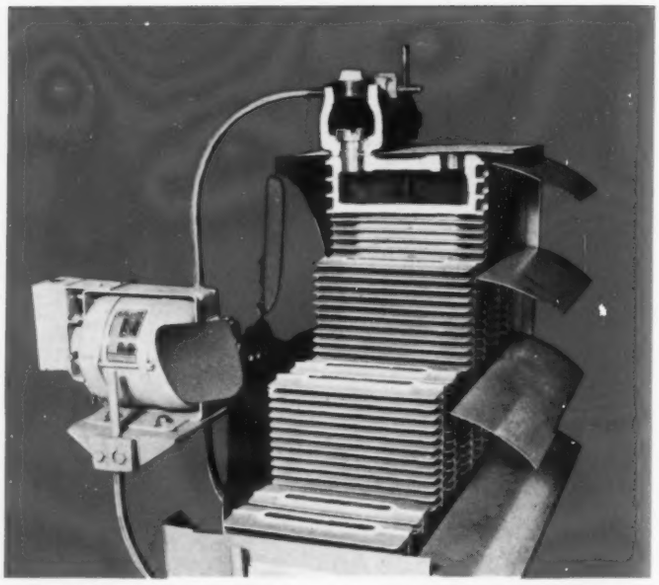
REG. U.S. PAT. OFF.

Syracuse, New York USA

MAIN OFFICE: SYRACUSE, N.Y. FIELD OFFICES: Albany, Atlanta, Baton Rouge, Birmingham, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Corpus Christi, Dallas, Denver, Detroit, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland, Oregon, St. Louis, St. Paul, Salt Lake City, San Francisco, Seattle, Tampa, Tulsa, Washington. **RESIDENT REPRESENTATIVES:** Baltimore, Md., Meriden, Conn., Reading, Pa., Richmond, Va., Springfield, Mass.
Crouse-Hinds of Canada, Ltd., Scarborough, Ont. Crouse-Hinds-Domex, S.A. de C.V. Mexico City, D.F. Peterco, Sao Paulo, Brazil

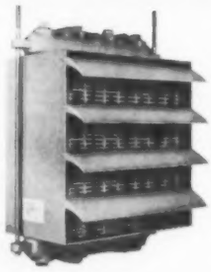
only with GRID*





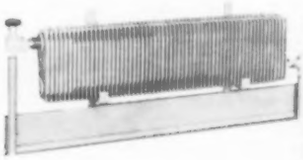
* UNIT HEATERS AND BLAST HEATERS

CAN YOU GET MAINTENANCE-FREE, TROUBLE-FREE *Life Long* HEATING SERVICE



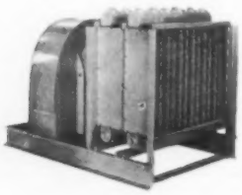
UNIT HEATERS

Available in Horizontal and Down Blow models. All cast iron built for steam pressures up to 250 PSI 450 Degrees.



RADIATORS

Various combinations with or without Grill covers. For use in confined areas where motorized units are not desirable. For low or high pressures to 250 PSI.



BLAST HEATERS

Wide range of sizes furnished with or without pressure blowers. Compact cast iron design requires less space.

It is possible because GRID is made to be maintenance-free, trouble-free . . . installations in 1929 are still operating without repairs. GRID construction and material - inside and out - account for GRID life long heating service.

GRID one piece cast iron steam chambers and headers eliminate internal corrosion . . . There's only one metal in contact with steam. No electrolysis is developed internally to eat away the heating elements. No leaks from rotted cores. And, GRID is leak-proof on steam pressures up to 250 P.S.I. 450° temperature. Specially designed units available for use on super heated steam.

GRID cast iron construction resists corrosion externally from acid fumes or other destructive elements in the atmosphere . . . cannot destroy GRID cast iron fin heating surface. Widely spaced fins cast integral with the steam chamber will not corrode and are easy to clean . . . will not "mat" on air intake side.

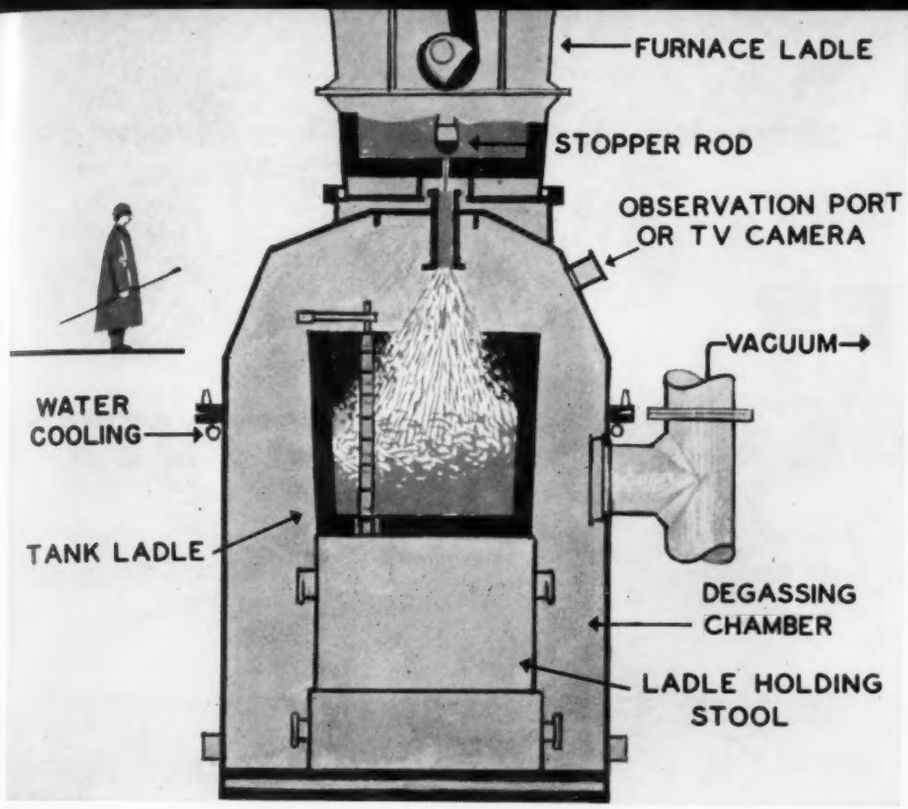
GRID design develops low outlet temperatures, and with proper fan volumes delivers warm comfortable air to the floor . . . no wasted heat at ceiling.

For trouble-free heating in your plant, write for complete information on GRID . . . ask for GRID products catalog No. 956.

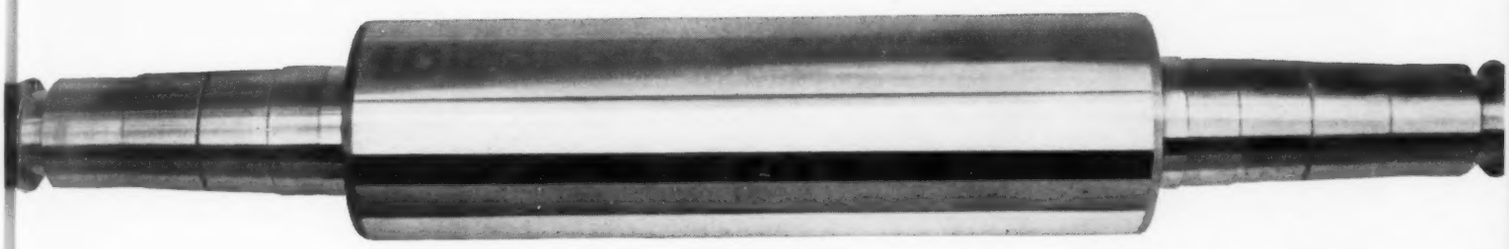
D. J. MURRAY MANUFACTURING CO.

Manufacturers Since 1883 WAUSAU, WISCONSIN

REPRESENTATIVES IN ALL PRINCIPAL CITIES



Our advanced steel-pouring techniques now permit us to pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases. The secondary ladle is then removed from the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.



When you use Bethlehem vacuum-degassed hardened steel rolls, you add many tons of production per roll. Made from steel that's sounder, tougher, cleaner . . . these rolls have proved their longer service in some of the biggest rolling mills in the country. As of today, there are over 3000 in service. There's no price extra! And deliveries are excellent. For all the money-saving details, get in touch with our nearest sales office.

LOOK FOR THIS "V" STAMP on the ends of the rolls you buy . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll . . . because Bethlehem forges hardened steel rolls **only** from vacuum-degassed steel.

Steel

for Strength
. . . Economy
. . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Another *plus* of Lightweight B&W Insulating Firebrick

LOWER THERMAL CONDUCTIVITY means

THERMAL CONDUCTIVITY COEFFICIENT*

B&W • IFB • 1.91

Competitive IFB • 3.04

NOTE: The above chart, based on available published figures, compares the difference in thermal conductivity between lightweight B&W IFB and the average of seven other leading insulating firebrick. This example, specifically covering 2300 F use limit insulating firebrick, is representative of the low conductivity of B&W IFB at all temperature levels.

*BTU/SQ. FT./IN. THICKNESS/HR./DEG. F.

All insulating firebrick are not the same. Published figures show wide variations in *all* of the important properties among the leading brands of IFB.

Take thermal conductivity. This important property affects fuel costs, temperature control and the speed with which a furnace heats and cools. Thermal conductivities range from a B&W low of 1.91 to a high of 3.47 for a competitive IFB—*almost a 100% difference in wasted heat and fuel costs.*

You are paying for insulating firebrick . . . make sure you get *all* the benefits. B&W—the originator of IFB—manufactures a full line of IFB with an experience-proved balance of light weight, high insulating value, high strength and long life.

For complete information on B&W Insulating Firebrick, write for Catalog R-38 to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

ONE OF A SERIES

LOWER FUEL COSTS

the payoff

- **14% lower fuel costs • 30 F lower casing temperature**
- **25% less time to reach operating temperature • 12 hours saved per cycle**

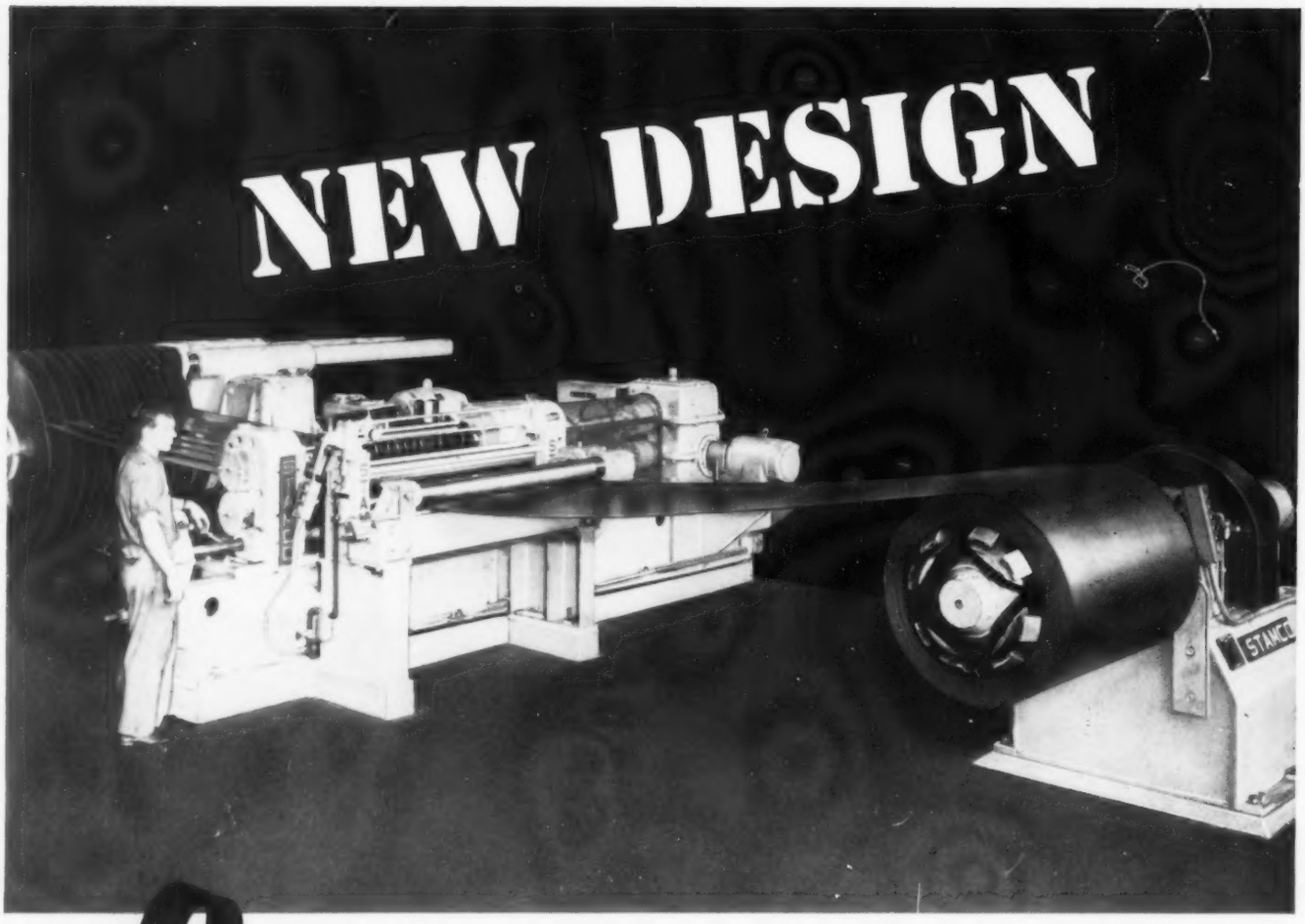
These are the results of a direct comparison of two furnaces of the type shown above, one lined with B&W IFB and the other with one of the better competitive insulating firebrick. That's how B&W pays off for a major steel company in their 8-stack, hood type, strip annealing furnaces. This is just one of many proofs in our files that "there is an important difference in insulating firebrick."

R-658

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION



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Unit will handle coils of 20 thousand pounds maximum weight with a maximum width of 52 inches. Attractively priced. Contact our specialized sales representatives for complete information.

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Slitting and Coiling Lines • Cut-to-Length Lines • Flying Shear Lines • Power Squaring Shears • Continuous Process Lines • Ferrous & Non-ferrous Mill Equipment

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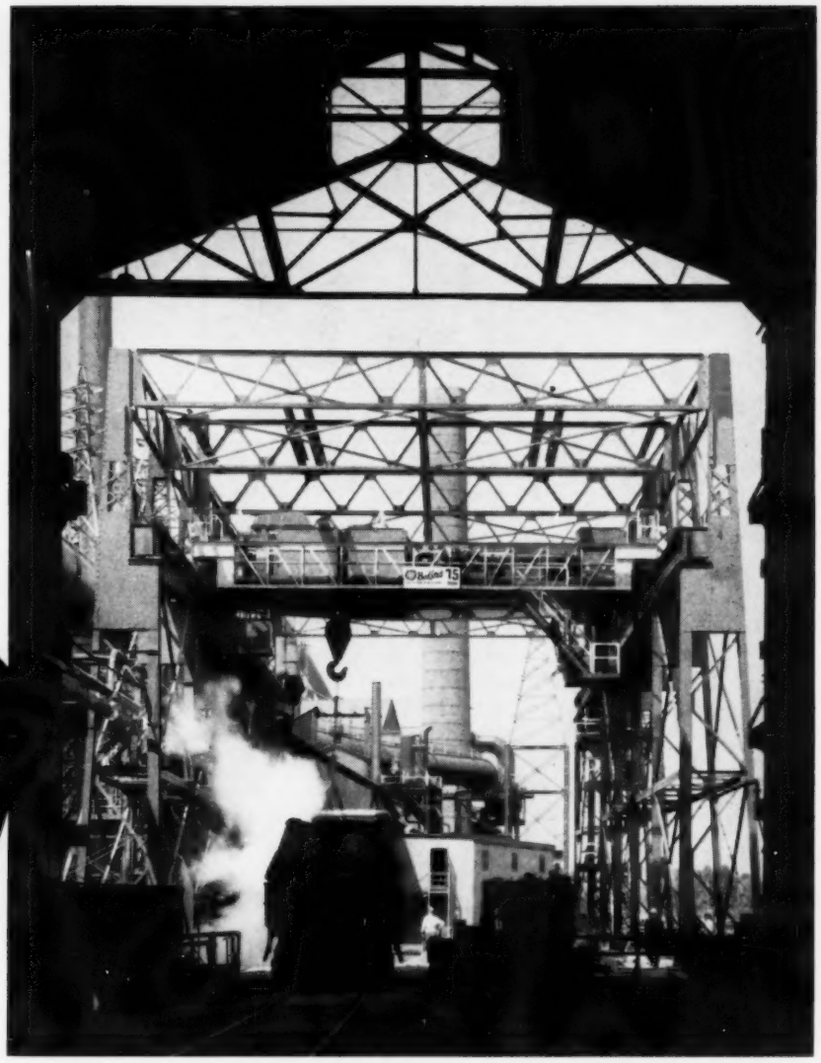
IN STEEL MILLS

WEIGHT LIFTING MADE EASY



Yuba designs and builds all types of custom steel cranes with lifting capacities of 5 to 1000 tons, for indoor or outdoor service.

Yuba-Bedford Steel Mill Cranes are working to plant capacity —24 hours a day —year after year

Two generations of steel makers have operated Bedford Cranes in mills from Pennsylvania to Peru. These are mills where the handling jobs are tough—where cranes work shift after shift under all conditions —and where there's time for only routine maintenance.

Hundreds of Bedford Cranes have been manufactured for leading steel producers...cranes that are specially designed and custom-built by Yuba to the tough requirements of the steel industry. Big lifting problems are made easy on every shift—for years!

Yuba designs, builds and erects all types of cranes including bridge, unloading and material handling, gantry and semi-gantry, floating and jib cranes. Also derricks, hoists and launching towers for defense ordnance.

YUBA

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FOR YOUR WETTEST JOBS

Wagner® Silicone Rubber Insulated Motors

Power-packed drip-proof polyphase motors that are exceptionally moisture-resistant . . . save you money in lower initial equipment cost for many applications

These are motors that are built to take on and tame the toughest jobs. Big, job-rated motors, available in frames larger than 445U, through 1000 horsepower. Perfect drives that can be used for station auxiliaries, in chemical plants, in rubber and paper mills and in the petroleum industry.

With motor coils completely sealed in a jacket of silicone rubber and housed in a compact, drip-proof enclosure, these Wagner® motors are suitable for use in highly humid atmospheres. They perform perfectly even after long exposure, and at elevated temperatures. Since moisture does not penetrate their tough silicone jackets, they are now used for many installations that once required totally-enclosed motors. Silicone rubber insulated motors cost less to buy than equivalent totally-enclosed fan cooled motors, since there is no need for expensive enclosures.

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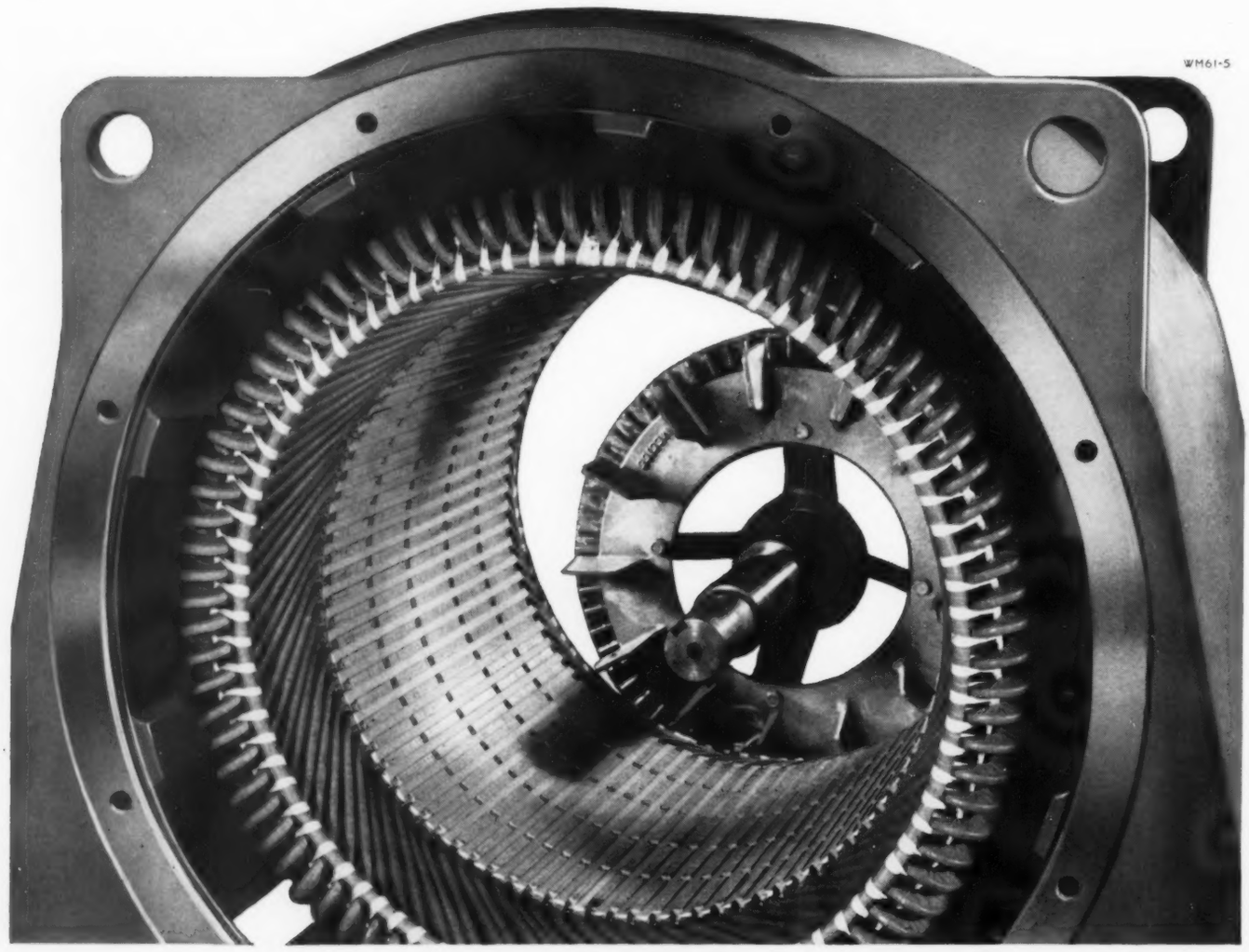
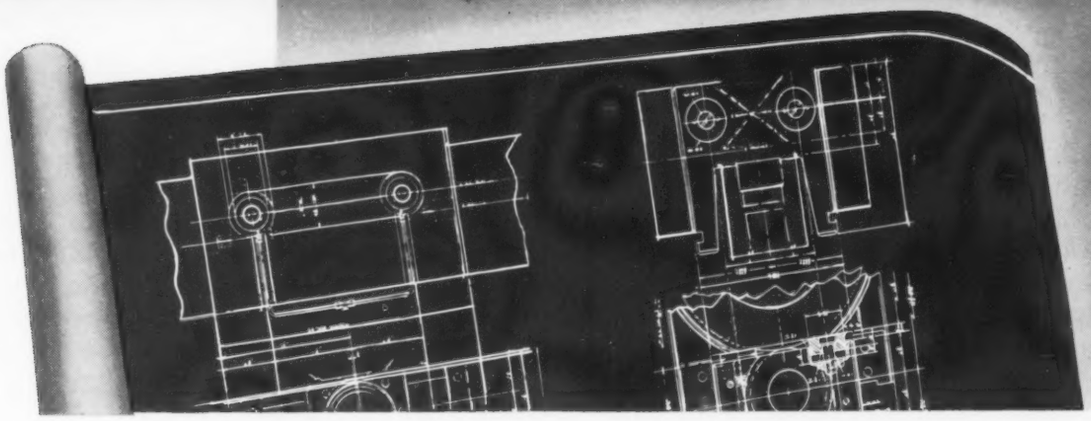


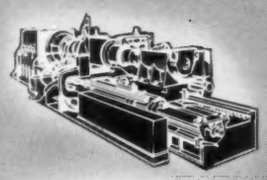


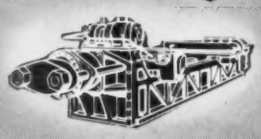
THE YOUNGSTOWN FOUNDRY & MACHINE CO. 75th ANNIVERSARY SERVING INDUSTRY SINCE 1886

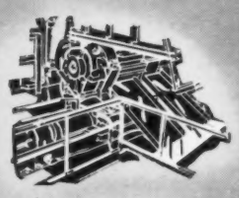
Blueprint of a new process

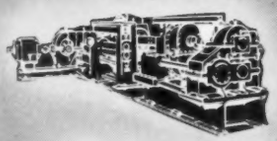
by "YOUNGSTOWN"

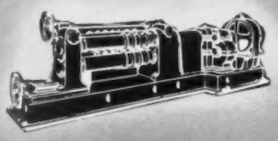
One of Many Major Developments for Industry during 75 YEARS of Service











Have you heard about Work Roll Shaping? It's a unique method for assuring uniform flatness of steel strip. Reports from users of installations already in operation indicate remarkable results. This is just one of the recent "Youngstown" developments which improve rolling mill operations. Complete information will be furnished, without obligation, on any of the following:

Hydraulic Work Roll Shape Control
Improves the quality of strip—economically

Automatic, Heavy Duty, Contour Roll Lathes
Modern design for templet or numerical control

New Carriage-Type Stretcher Levelers
Sizes from 10,000# to 4,000,000#. Fast, efficient

500 fpm—81" Sheet Scrubber Line
Cleans sheets up to 76" wide and .250" thick

New Rotary-Type Plate Scrap Chopper
Unique reciprocating design prolongs knife life

Coil Processors and Scale Breakers
New concept of coil processing and scale breaking

Other recent contracts range from complete turnkey installations to auxiliary components. Whatever the need—large or small—you benefit from "Youngstown" experience.

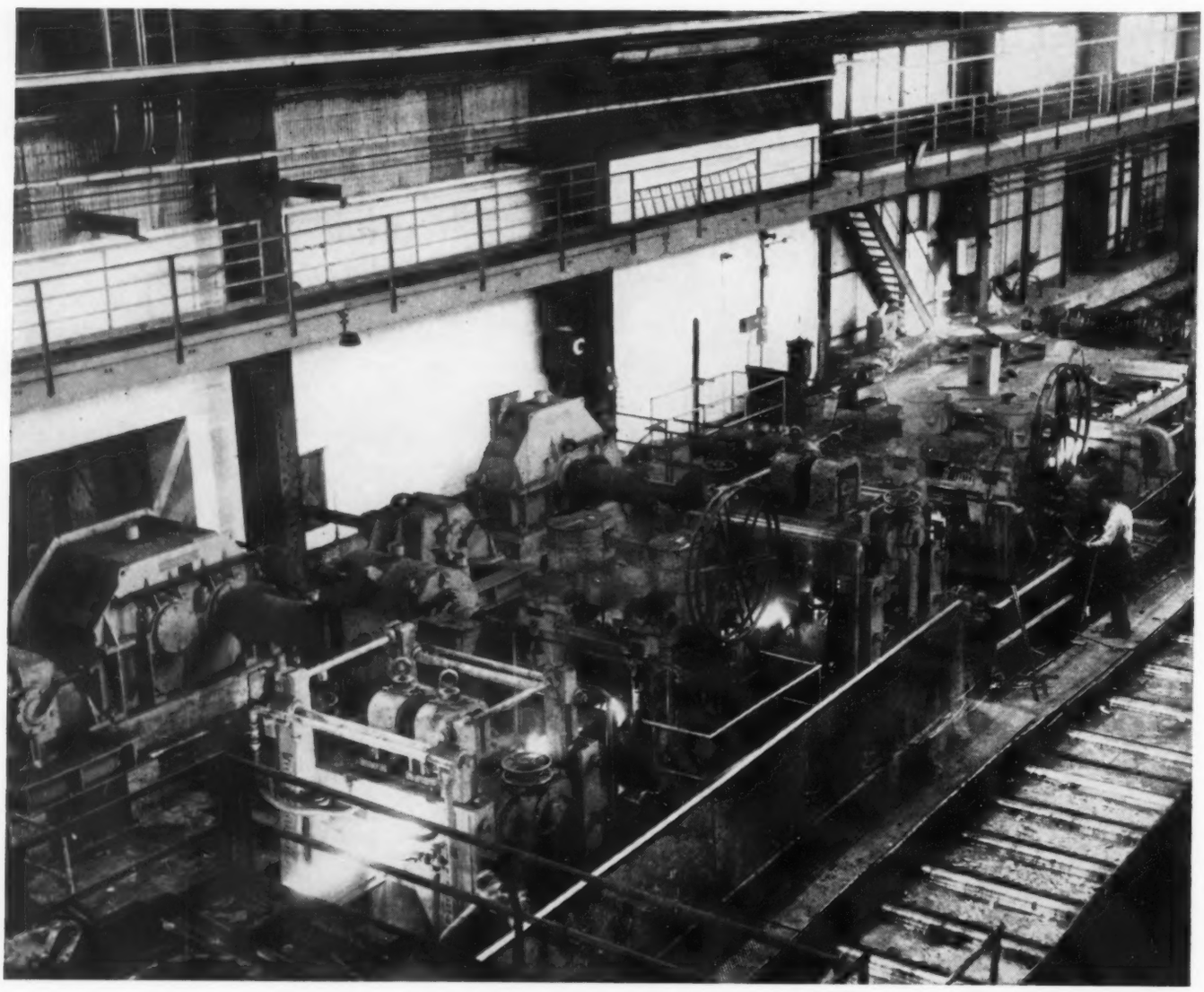
Complete Engineering
Contract Services
Rolling Mill Machinery
Special Machinery
Paralloy Rolls
Ductile Iron Rolls
Castings up to 100,000#

The Youngstown Foundry & Machine Co.

Youngstown 1, Ohio

New, faster **BIRDSBORO** *20" Continuous Mill produces up to 100 tons per hour*

This 20" Continuous Mill engineered and built by Birdsboro for Aristoloy Steel Division of Copperweld Steel has two vertical and two horizontal roll stands. The use of vertical and horizontal stands permits the mill to roll rounds, squares and flats without twist guides. The use of bevel gear angle drives for the vertical stands permits placing all the main mill motors on the same level in the motor room. Copperweld has successfully rolled 5-inch squares, although design capacity is $2\frac{1}{2}$" to $4\frac{3}{4}$" squares. The mill is designed to take blooms rolled direct from the ingot by the breakdown mill without reheating. Even high chrome nickel grades of steel that normally require reheating after reduction to 5- to 7-inch squares can be reduced direct to the smallest billet sizes without reheat. The installation of this Birdsboro mill with its many design extras has helped give Copperweld new flexibility of production while reducing costs. Birdsboro custom engineering can solve your production problems and open new profit doors for your mill operations. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pennsylvania; *District Office:* Pittsburgh, Pennsylvania.



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BIRDSBORO

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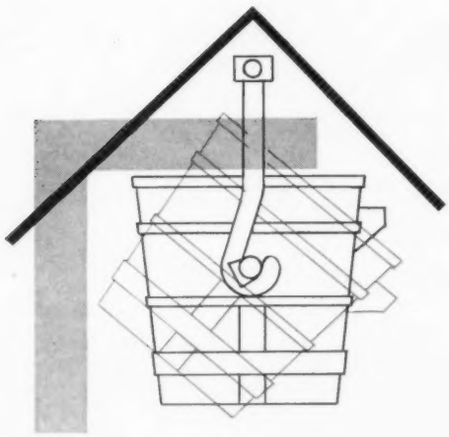
STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL



STEEL ANGLES

A UNITED Nations study issued in 1950 indicated some facts about our iron ore supply which were already abundantly clear to a number of steel companies. We faced a severe problem and it is most heartening to realize that continued and concerted effort on the part of the industry has finally provided a solution to it.

The United States was credited with 6.4 per cent of the world's supply of iron ore, yet it produced 49 per cent of all the ore mined throughout the world. India, on the other hand, was estimated to have 21 per cent of the world's iron ore and produced only 1.2 per cent of the total amount mined on a world wide basis.

Our supply in relation to the demands made on it was reaching a critically low point and if the United States attempted to meet full requirements from domestic sources of direct shipping ore, they would be virtually exhausted within a decade or two. This crisis was fully recognized by the steel companies of the United States. A great deal of time, exploration and capital has been invested in the past decade to remedy the situation.

The problem began to develop during World War II, at which time an average of close to 100,000,000 tons of ore was produced annually throughout the country, while some 85,000,000 tons of this total came from the Lake Superior region. This huge quantity constituted a substantial increase over the production figures of the 1930's which never exceeded 72,000,000 tons for the nation as a whole in any one year, or 62,000,000 tons for the Lake Superior region. In fact, many of the years in that decade witnessed much lower ore production, so that the average output for the country during the ten-year period was about 40,000,000 tons a year. At this rate of production, the reserves on the Mesabi Range and elsewhere seemed virtually limitless and inexhaustible.

Wartime production was abnormal, but the "abnormal" state continued in the post-war period as the demand for steel grew to unprecedented heights culminating in an ingot production of 117,000,000 tons in 1955 and 115,000,000 tons in 1956. This high rate of production brought with it increasing pressures on the available iron ore supply. The steel industry pressed an exhaustive search throughout the world for new bodies of ore. It was hoped that high-grade direct shipping ore would be found, and rich bodies were discovered in Quebec, Liberia and Venezuela. The iron content of the Quebec ore averaged close to 55 per cent. In Liberia, a particularly rich ore was discovered with an iron content of 65 per cent, and in Venezuela exploration parties literally uncovered a mountain of rich ore, the iron content of which was in the area of 60 per cent.

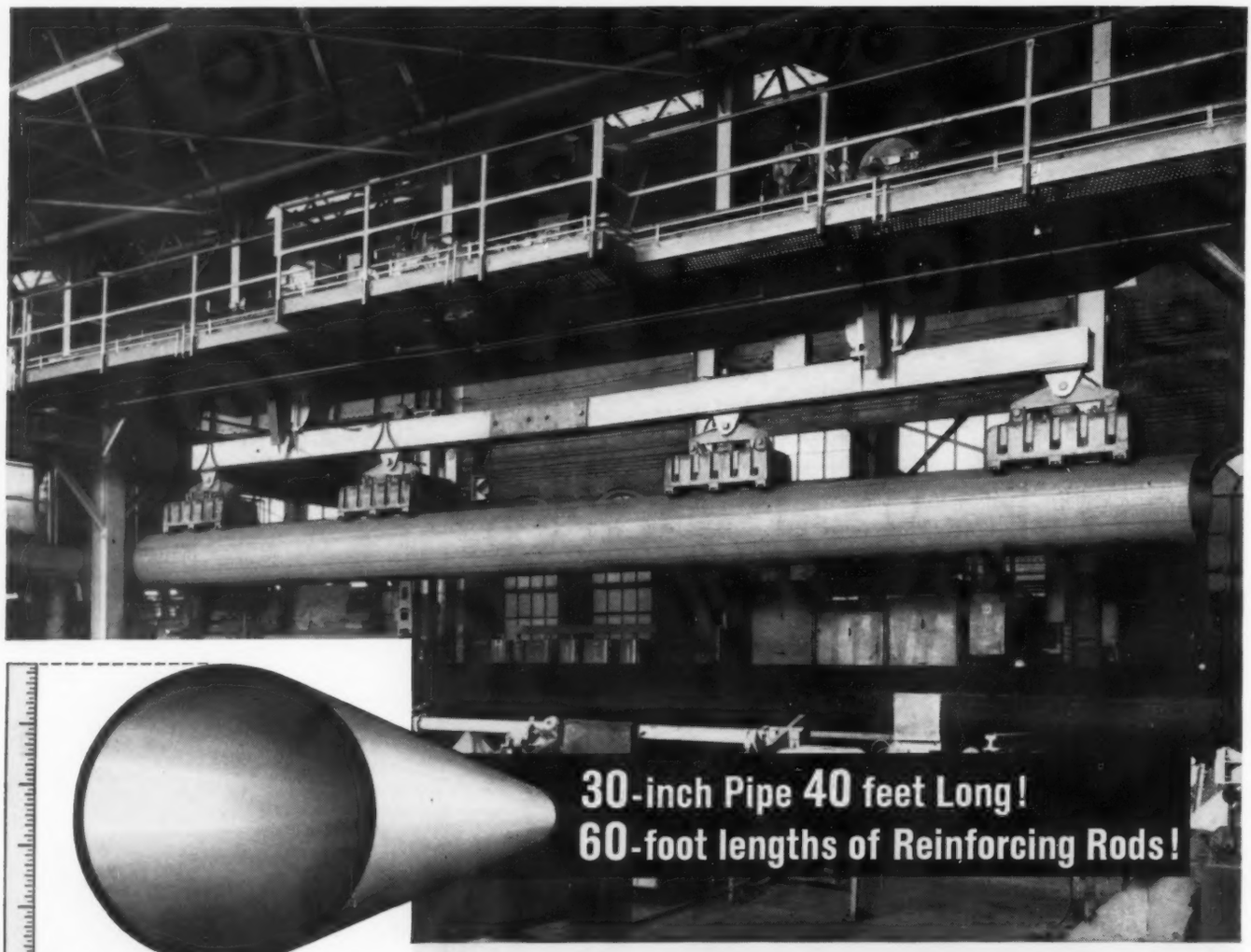
The program to fulfill iron ore requirements included another phase in addition to exploration for new sources. This was a widespread operation directed at preparing for use the known supplies of lean low-grade iron ore which existed in vast quantities in the United States. Much of this ore was hard taconite whose iron content varied from 18 to 30 per cent.

Plants were constructed that would treat this material, as well as other types of lean ores, and render it satisfactory for use in the blast furnace. This was achieved by producing an ultimate product with an iron content of over 60 per cent.

Further, new bodies of low-grade ore were discovered and have been developed. One of these is operated by the Quebec Cartier Mining Co., a Canadian subsidiary of the United States Steel Corp. The ore, as mined, has an iron content of 29 to 30 per cent and can be readily concentrated so that the final product has a 66 per cent iron content.

The new discoveries and the beneficiation of known lean ores have solved the problem of iron ore supply for the American steel industry. It is difficult to estimate how long these supplies will last for this will depend on the rate of consumption. However, under present projections there should be no concern about iron ore supply for the next 30 years. Such a period may seem long, but it is only prudent that a corporation, which is of its nature a perpetual entity, should provide the raw materials on which its existence is dependent for as long a period as is practicable.

The development of new reserves and the beneficiation of lean ores have required a tremendous capital investment. The outlay was so great that in some instances a number of companies shared the burden. It would be difficult to determine the total expenditure with any degree of exactness, but one could safely put the figure expended during the past ten years at more than $1,400,000,000. This is indeed a large amount and when we consider that it represents the cost of only one raw material in the steelmaking process and is in no way related to the production facilities themselves, it brings into sharper focus the enormous capital needs of the iron and steel industry in this country. Such capital requirements can only be met by large, efficient, profitable corporations who have the confidence of the investor. ▲



PIONEER INSTALLATION
Reinforcing rods, weighing up to 5 tons per bundle, are handled without slings ...without spacers between stored layers. EC&M magnets have narrow width to fit into production cradles and between storage rack posts.

ALL MOVED QUICKLY, SAFELY WITH EC&M MAGNETS!

At Bethlehem Steel Company's Line Pipe Mill in Steelton, Pa., pipe and rods are moved without chains, without slings, without ground men. The result—no bottlenecks!

For any handling requirement like this, EC&M has the right size and type of magnet. Let us prove that EC&M magnets can move your pipe and rods just as quickly, just as safely—and economically, too.

NEW BROCHURE 1311 fully describes these operations. Write for your copy. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio.

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Development of USSR Iron and Steel Industry

by IVAN DENISENKO, Economist
Economic Research Institute
and ROMAN BELAN
Metallurgical Engineer
Head, Iron and Steel Industry Dept.
State Planning Commission, USSR

. . . . primary emphasis is being given in the USSR to the development of their iron and steel industry . . . . this work cannot but be of interest to the steel operators and engineers in the Western World . . . .

THE art of obtaining iron from ore, which had originated in very ancient times, has attained immense development. The development proceeded along different lines in the various countries.

At the close of the nineteenth century, an iron and steel industry was set up in the south of Russia with the participation of foreign capital, while the Urals, which had formerly been the country's iron and steelmaking center, came down to second place.

The economic crisis that broke out in the early 20th century retarded the growth of iron and steel output. The monopolies which by that time had formed in the mining industry had ruined a great number of minor enterprises, and affected the output of metals.

Russia's iron and steel industry attained its highest level to that time on the eve of World War I. In 1913 it produced 5,200,000 net tons of cast iron, 5,400,000 tons of steel and 4,400,000 tons of rolled metal. The engineering level of Russian metallurgical plant was lower than that abroad. The enterprises had low-efficiency blast and open hearth furnaces and rolling mills. Almost two thirds of all the blast furnaces had useful volumes of up to 10,590 cu ft, while the capacity of open hearth furnaces averaged 27.5 to 33 tons. Hard, physical labor was employed at the obsolete rolling mills. The unloading of raw materials and fuel, the charging of furnaces, the discharge of metal from the furnaces and its removal was done by hand. Labor efficiency was one half that at European plants and one fourth that in the U. S.

Russia's iron and steel industry was to a great extent dependent on foreign capital. Foreigners owned more than 60 per cent of the joint-stock capital in the entire Russian iron and steel industry, including 90 per cent of the capital in the south's metallurgy. The older plants in the Urals had an insignificant scale of production and low engineering level. These enterprises produced cast iron in small blast furnaces ,operating mainly on charcoal.

World War I and the civil war that followed it brought great devastation to Russia's iron and steel industry. In 1920 the plants of the Soviet republic produced 127,600 tons of cast iron, 213,400 tons of steel and 161,700 tons of rolled metal.

The first economic plan for the rehabilitation and development of the national economy was drafted in 1920. The first 5-year plan (1928–32) laid special stress on the industrialization of the country, which called for an immense increase in iron and steel production. This involved a basic reconstruction of the old plants and the construction of new ones provided with the latest equipment. The construction of such big enterprises as the Magnitogorsk Combine in the Urals, the Kuznetsk Combine in Siberia, the Zaporozhstal, Azovstal and Krivorozhstal plants in the Ukraine, and the Novy-Tagil plant in the Urals were launched under

this plan. In 1932, at the close of the first 5-year plan period, the construction of the first stage of the Magnitogorsk and Kuznetsk Combines had been completed and they started to put out metal. In those years American engineers were invited to consult in the designing and construction of these two plants and of some other new projects. They took part in the revision of the initial designs of these paramount metallurgical enterprises. Naturally, the elaboration of new designs prolonged somewhat the completion of the Magnitogorsk and Kuznetsk works projects.

The iron and steel plants in Dnieprodzerzhinsk and Makeyevka were subjected to fundamental reconstruction.

In the course of the first 5-year-plan period a total of 41 blast furnaces, 65 open hearth furnaces and 32 rolling mills were put into operation. The first plant producing ferroalloys was erected in the city of Chelyabinsk in the Urals. The same period saw the construction or reconstruction of coke-chemistry plants, iron-ore mines, refractory plants.

The commissioning of new plants in the Urals and Siberia and the reconstruction of the old Ural plants served to set up a second metallurgical base in the east of the country.

A basis for the further and still faster rise of the iron and steel industry was created in the first 5-year plan period.

The fulfillment of the second Soviet 5-year plan (1933–37) saw the commissioning of 19 blast furnaces, 82 open hearth furnaces and 47 rolling mills. The world's largest, for that time, 1700-cu yd blast furnace was put in operation at the Zaporozhstal plant in 1937.

Major pipe works were built and commissioned in the town of Pervouralsk in the Urals and in Nikopol in the Ukraine.

THE YEARS OF WAR

In 1941 the labor of the Soviet people was interrupted by the sudden attack of Nazi Germany on the Soviet Union. The temporary occupation of the south of the country, whose enterprises had been putting out two thirds of all the steel and rolled metal before the war, inflicted great damage on the USSR's iron and steel industry. Some 62 blast furnaces, 213 open hearth furnaces and 248 rolling mills were destroyed in the areas occupied by the enemy. By the end of 1941 the output of iron and steel in the USSR was reduced to less than a third.

From the very first days of war, measures were taken to increase metal production in the Urals and Siberia. Metallurgical production facilities moved from the South were being put in operation in the Eastern areas of the country. At the same time new shops and plants were being built in those regions at a fast rate. In the four years of war 10 blast furnaces, 29 open hearth furnaces, 16 electric steel-smelting furnaces, two bessemer converters, 15 rolling and six pipe mills, and 13 coke batteries were put in operation at the iron and steel works in the East.

Among the plants built anew in the years of war were: the first section of the Chelyabinsk Iron and Steel works, the Chelyabinsk pipe plant (the Urals), the Kazakh and Uzbek Iron and Steel plants, and ferroalloy plants in the town of Aktyubinsk (Kazakhstan) and Stalinsk (Western Siberia). Two blast furnaces, five open hearth furnaces and two rolling mills were commissioned at the Magnitogorsk Iron and Steel Combine. An electric steel-smelting and a metal-rolling shop for high-grade steels were put in operation at the Kuznetsk Iron and Steel Combine.

The production of cast iron in 1945 amounted to 9,700,000 tons, steel 13,400,000 tons, rolled metal 9,350,000 tons.

POSTWAR DEVELOPMENT

After the war the USSR started fulfilling its 5-year plan for the rehabilitation and development of the national economy (1946–50). That was the fourth plan covering a period of five years. The fulfillment of this plan resulted in iron and steel output surpassing the prewar level by 45 per cent. The fourth 5-year plan period advanced the Soviet Union to the first place in Europe and the second place in the world as regards iron and steel output.

The iron and steel industry of the south was restored and started producing more metal than it did before the war. The iron and steel industry of the east continued to develop, and plants were built in Transcaucasia and Central Asia.

Under the fifth 5-year plan (1951–55) major attention was paid to introducing new equipment and technology, and to intensifying the metalmaking processes which resulted in further improvements in the utilization of plant. The ratio of utilizing the blast furnace useful volume and the yield of steel per sq ft of furnace hearth in open hearth furnaces increased by more than 20 per cent. Many of the blast furnaces were at that time shifted over to operating with a constant controlled blast humidity, and the share of agglomerate in the blast furnace charge was increased.

In the course of five years the output of cast iron increased by 15,500,000 tons, steel by 18,700,000 tons and rolled metal by 15,800,000 tons.

The sixth 5-year plan covered the period from 1956 to 1960. However, the solution of a number of economic problems called for a longer period of time, and so a 7-year plan for the country's economic development (1959 to 1965) was drafted in 1958.

NEW MACHINERY AND TECHNOLOGY

The growth of iron and steel output in the USSR was due both to the commissioning of new production capacities and to the introduction of new machinery and technologies. The following table characterizes the scale on which some types of new machinery and technology were introduced in the nine years preceding the 7-year plan period (1950 to 1958).

The 7-year plan of economic development for 1959–65 provides for the speeded-up development of the iron and steel industry. The gross output and the growth of production of ferrous metals under the 7-year plan are characterized by the following data.

	gross output		*Mean annual growth rate for seven years, per cent*
	1965, in million tons	*1965, in per cent of 1958*	
Cast iron	72–77	164–177	7.3–8.5

Steel	95–100	157–166	6.7–8.7
Rolled metal	72–77	153–163	6.2–7.2
Iron ore, commercial	165–176	169–180	7.8–8.7

The fulfillment of the 7-year plan in the field of iron and steelmaking calls for considerable capital investments for the enlargement of the functioning enterprises and for building new ones. It is for these purposes that a sum of $25,000,000,000 (100,000,000,000 rubles) has been allotted, which is 2.4 times more than had been invested in the preceding seven years (1952–58). Two thirds of these capital investments are to go into raising the production capacities of the functioning enterprises. This will be done by enlarging and reconstructing them and modernizing their equipment. The remainder will go into the construction of new enterprises.

In the course of the seven years new capacities will be commissioned so as to provide for the additional output of no less than 26,000,000 to 33,000,000 tons of cast iron, 31,000,000 to 40,000,000 tons of steel and 25,000,000 to 32,000,000 tons of rolled metal.

In conformance with the 7-year economic development plan, Soviet planning bodies draw up yearly plans. The results of the fulfillment of the plan for 1959 and for the first six months of 1960 show that the 7-year program is being carried out successfully, both as a whole and as regards the iron and steel industry.

In 1959 three large blast furnaces, ten open hearth furnaces, three electric steel-smelting furnaces, two bessemer converters, seven rolling mills and five coking batteries were commissioned. Additional capacities for the annual output of 25,000,000 tons of iron ore were put in operation, among them the Novo-Krivorozhsky Ore Mining and Dressing Combine with a capacity of 10,000,000 net tons of ore per year.

The plan for 1960 provides for the commissioning of five big blast furnaces, ten large open hearth furnaces, three electric furnaces, six modern rolling mills, a shop for the cold-rolling of sheet steel and a number of units for the manufacture of steel and iron pipes, as well as eight coking batteries.

If we apply to the remaining six years of the 7-year plan period the actual rate of iron and steel production growth of 1959, i.e., nine per cent, then approximately the following quantities of ferrous metals will be put out in 1965:

Cast iron	80,000,000 tons
Steel	110,000,000 tons
Rolled metal	88,000,000 tons

At the iron and steel works of the Stalino Economic Area (Donbas) pressure has been launched to attain in 1963 the level of cast-iron, steel and rolled metal output, that is planned for 1965. Earlier than planned, two large blast furnaces, seven high-capacity open hearth furnaces, two converter shops, five rolling mills and other industrial objects are to be built. More than a half of all the blast furnaces in this economic area are already operating on natural gas injection. The largest of them are being shifted over to operate with increased top pressure. They employ an oxygen-enriched blast, and the air fed into the furnace is heated to temperatures that exceed 1800 F. A large number of engineering novelties, most of which have been proposed by personnel of the enterprises, are being employed there in steelmaking and rolled metal production.

All the blast furnaces of the Dniepropetrovsk Economic Area will be put to operate with natural gas injection and some of them will employ oxygen-enriched blasting. The furnaces are to be shifted over to operating with increased top pressure (up to 22 psi) and extensive use is to be made of self-fluxing agglomerate and baked lumped ore. In addition 12 blast furnaces will be equipped with evaporative-cooling systems, and seven more furnaces will have all-round automatic temperature control.

In the Dniepropetrovsk Economic Area all steel is to be made with the use of oxygen. Under consideration is the use of compressor and turbine air on 24 open hearth furnaces with the purpose of intensifying the smelting process. Almost all the open hearth furnaces will operate on natural gas. Four continuous casting installations with vacuum metal processing are to be put in operation. There is a project which provides for shifting all steelmaking converters over to 1½ times greater melt.

The greater part of the increase in rolled metal production in the Dniepropetrovsk Economic Area is to be achieved by modernizing the rolling mills, increasing the efficiency of soaking pits, introducing simultaneous rolling of two ingots on blooming mills and cutting down the idle time of rolling mills.

A THIRD METALLURGICAL BASE

Changes in the territorial distribution of metallurgical enterprises is one of the specific features of the development of the iron and steel industry according to the 7-year plan. Up till now the bulk of the metal was produced by the enterprises of the first and second metallurgical bases located in the Ukraine and the Urals. The 7-year plan provides for the foundation of a third metallurgical base. It will comprise factories to be built east of the Urals, in Siberia and Kazakhstan.

It will include, among others, the functioning Kuznetsk Combine, the Karaganda plant that is now being put in operation and has already yielded its first metal, and the West-Siberian Iron and Steel works now under construction. This 7-year period will see the commissioning of the Taishet plant in East Siberia. Another plant is to be built in this part of Siberia after 1965, and an iron and steel works is to be built in Barnaul (Altai Territory).

Soon after 1965 a fourth (Kustanai) and fifth (Transbaikal) metallurgical bases may be created in the USSR; they will be located on the coking-coal and iron-ore deposits of South Yakutia and in the iron-ore deposits in Kazakhstan.

To ensure the correct location of the iron and steel industry, prospecting and surveying work is being constantly carried out in the Soviet Union according to plan. The iron ore and fuel reserves prospected in the country's eastern areas can ensure the output of more than 44,000,000 tons of cast iron a year.

The iron and steel plants that are being built or planned to be built in the East are based on the following iron-ore and fuel deposits:

	Plants	*Iron-ore base (deposits)*	*Fuel sources (basin)*
1.	West-Siberian	Altai-Sayany ore deposits (in the southern part of West Siberia)	Kuznetsk Basin
2.	Karaganda	The Atasuy Group and Atanar deposit (in Kazakhstan)	Karaganda Basin
3.	Taishet (First East-Siberian)	Korshunov and Rudnogorsk deposits in Angara—Ilim region	Kuznetsk Basin and subsequent addition of local coals
4.	Barnaul	Lisakov deposit in Kustanai region	Kuznetsk Basin
5.	Krasnoyarsk (Second East-Siberian)	Nizhne-Angarsk deposit of Angara-Pitsk basin	Kuznetsk Basin and addition of local coals
6.	Kustanai	Lisakov deposit in Kustanai region	Karaganda and Kuznetsk Basins
7.	Transbaikal:		
	(a) first variant on Alden ores	Taiga and Pioneer deposits (Yakut ASSR)	South-Yakutian Basin (Neryungrin and Chulmaken deposits)
	(b) second variant on Berezovo ores	The Berezovo deposit in Chita region	South-Yakutian and Bukachacha Basins

Each new enterprise will have a production profile of its own. The West-Siberian plant now under construction not far from the Kuznetsk Iron and Steel Combine will put out small and medium-size sections and rolled wire. About a third of the rolled metal is designed for the manufacture of metal goods and pipes at plants that are to be built in the same area.

The Karaganda Iron and Steel works, specializing in thin hot and cold-rolled metal sheets, white tin, bent profiles, etc., is being built near the town of Temir-Tau in the Kazakh SSR, next to the operating Karaganda pig-iron processing plant. The nearness of a fuel and ore base, as well as of the chief nonore raw material, will permit this works to produce metal at the lowest possible cost. The Karaganda works will be supplied with water by the 310-mile long Irtysh-Karaganda Canal now under construction. The waters of the Irtysh river will be elevated by pumping stations to a height of 1550 ft and delivered to the area of Karaganda by the 65 to 130-ft wide and 13 to 20-ft deep canal. This will be a fundamental solution to the problem of supplying water to the iron and steel and other enterprises that have been built and are being built in these formerly waterless desert steppes of Kazakhstan. The canal is to be completed within five years.

The Taishet Iron and Steel plant is to put out a wide assortment of rolled sheet metal to meet the growing demands of Siberia. About a third of the sheet metal produced here will be consumed by its own electric pipe welding shop for the manufacture of electrically welded pipes with diameters of 0.4 to 40 in. Large quantities of bent profiles and centrifugally cast-iron pipes with a wide range of diameters and wall thicknesses will be put out here.

The construction of the Taishet plant in Irkutsk region is to be started in the current 7-year period, the construction of the Barnaul plant will probably be started immediately after 1965, and it is expedient to start the construction of the Krasnoyarsk plant after the present 7-year plan period, so as to have it produce rolled metal in the 1970's.

The first plants to be enlarged will be those that for a number of reasons show the highest efficiency of capital investments. Among these enterprises are the Magnitogorsk, Kuznetsk and Nizhne-Tagil Iron and Steel works, the Dnieprodzerzhinsk, Zaporozhstal and Makeryevka plants.

These seven years will see the considerable enlargement of plants in Krivoy-Rog, Mariupol, Novolipetsk, Cherepovets and Novotroitsk (The Orsk Khalilovo Iron and Steel works).

The extent to which metal output will increase at the functioning enterprises may be judged by the Magnitogorsk Iron and Steel works. The technical reconstruction there will result in the output of rolled metal increasing by more than 1.6 fold and reaching 9,300,000 tons a year by the end of the 7-year period.

Great importance is attached to further raising metal production in the central areas of the country. The plant that will undergo the greatest development here is the Novolipetsk Iron and Steel works. It will have an output capacity equal to that of the present-day Magnitogorsk Iron and Steel works and will become the chief manufacturer of electrical sheet steel, pipes for gas mains, sheet iron and bent profiles in this part of the country.

The development of the iron and steel industry in the central areas of the USSR is based on the practically inexhaustible iron-ore resources of the Kursk magnetic anomaly and Donets coking coals. In the current 7-year period the mines built on the site of the Kursk magnetic anomaly will fully provide with iron ore the Lipetsk and Tula iron and steel plants, eliminating delivering it from Krivoy-Rog. Subsequently they will serve as basis for creating a second big metallurgical plant in the area of Kursk-Belgorod-Oryol.

Under the 7-year plan the Ukraine's iron and steel industry which forms the foundation of the country's first metallurgical base is being developed as well.

Construction is going on of the second part of Krivoy-Rog iron and steel plant which is to become one of the country's biggest enterprises. New production capacities are being put in commission at the plants of the Donbas and the Dneiper area.

In 1965 according to plan, the Ukraine is to produce 34,800,000 tons of cast iron, 34,700,000 tons of steel,

27,200,000 tons of rolled metal and 88,000,000 tons of iron ore.

The 7-year plan will add 130,000,000 net tons of iron ore annually increasing output to 220,000,000 tons. It provides for the development of a number of new iron-ore deposits discovered in Siberia, the Urals and in Kazakhstan. This implies the development of the Nizhne-Angarsk deposit in Eastern Siberia, the Kachkanar deposit in the Urals, the Sokolovo-Sarbai, Atasuysk and Lisakov deposits in Kazakhstan.

From geological exploration, the prospective resources of iron ores in Eastern Siberia are estimated at 15,000,000,000 net tons. The largest among these deposits is the Angaro-Pitsk iron-ore basin whose prospective reserves are estimated as 5,550,000,000 tons of ore. A study of the technological properties of this ore has shown that baking, a magnetic method of benefication, permits extraction of a concentrate with 59 to 60 per cent iron content.

A rich iron-ore bearing area, the Angara-Ilim district, has been discovered on the territory of Irkutsk region. The Korshunov deposit of this region, where a major ore-dressing plant is being built, will serve as iron-ore base for the Taishet Iron and Steel works.

Of great importance for the iron and steel industry of the Central Urals is the development of the Kachkanar iron-ore deposits. The ores there occur on the surface, which permits large-scale open pit mining. The Kachkanar ores readily lend themselves to benefication by the electromagnetic separation method. They belong to the type of lean vanadium ores with a low titanium content and a very low content of harmful admixtures, sulphur and phosphorus. The iron content of the balance ores varies between 14 and 35 per cent.

One of the country's biggest ore-dressing plants which will handle up to 36,300,000 tons of crude ore a year is being built at the Kachkanar mountain, at a distance of 62½ miles northward from the Nizhne-Tagil Iron and Steel works and to the south of the Serov works.

The Sokolovo-Sarbai Ore-Dressing plant will serve as chief iron-ore base of the South Urals' iron and steel industry. The construction of the first section of the Sokolovo-Sarbai ore-dressing plant was completed in 1959. By 1965 its output capacity will reach 29,200,000 tons of ore per year.

A large factory for the production and lumping of high-grade concentrate with an up to 65 per cent iron content is to be built at the plant.

Great importance is attached to the utilization of the iron-ore wealth of the Kursk magnetic anomaly which is a raw-material basis for the center and south of the country. The world's largest iron-ore deposits have been found in the Kursk, Belgorod and Oryol regions. The quantities of rich ore alone, which may be processed without being dressed, are estimated at approximately 22,000,000,000 tons, which is several times more than in the famous Krivoy-Rog basin in the USSR. Industrial development of the Kursk basin progressed rather slowly till recently, because the ores were deep and more important, the presence of several water-bearing levels in the overburden.

In 1934 the Lebedinsky deposit of rich iron ore, which had a reserve of about 200,000,000 tons was discovered in the Belgorod region. This ore occurs comparatively near the surface and may be worked by open-pit mining methods, but requires draining of the overburden.

Another unique deposit of rich ores with 60 and more per cent iron content, low (5 to 6 per cent) silica content and no sulphur or phosphorus, was prospected in the area of Belgorod. This is the Yakovlev deposit with a thickness of ore bed of 26 to 382 yd and a bed width of about 390 yd. A still greater deposit, the Gostishchevsky, was found in the same area in 1955. The latest data show it to possess 11,000,000,000 tons of rich iron ore, including 2,200,000,000 tons of industrial reserves. This is the largest of the deposits of the Kursk magnetic anomaly.

Thick iron-ore beds occurring at the depth of 142 to 144 yd and containing over 60 per cent of iron have been found in other places in the Belgorod iron-ore area.

The reserves of rich iron ore in the Belgorod area of the Kursk magnetic anomaly alone are estimated to total not less than 16,500,000,000 tons. The fact that the ore beds in the Belgorod area occur at a depth of 490–545 yd, and deeper calls for mining by underground methods and for the solution of a number of complicated engineering problems.

Open-pit mining has been intensified due to the construction of the Southern Ore Mining and Dressing plant in the Krivoy-Rog basin. In the initial period of this plant's work some 11,000,000 tons of raw material were obtained per year for the dressing factory and 3,300,000 tons of overburden moved.

In the current 7-year plan period the output of iron ore in the Krivoy-Rog basin is to increase by 50 per cent. The plan provides for the construction of five ore-dressing plants and 14 mines.

The Novo-Krivorozhsky Ore Mining and Dressing plant, put in operation in 1959, will mine by the open-pit method 11,000,000 tons of ore per year and put out about 5,500,000 tons of concentrate with an iron content of 60 per cent.

The Central Ore-Dressing plant which will be the first to dress lean ores subjected to preliminary magnetic-recovery baking in rotary kilns is now being built in the Krivoy-Rog basin. Construction is under way of the Southern Ore Mining and Dressing plant No. 2 which was to be commissioned in 1960 and the "Deep-Giant" mine with an output capacity of almost 8,300,000 tons of rich ore per year. The mine is being equipped with a multi-cable machine for raising the ore by means of two 55-ton skips.

BLAST FURNACE PRODUCTION

Blast furnace production in the USSR has been developing along the lines of a continuous increase in blast furnace volume and improvement of smelting technologies. A blast furnace with a useful volume of 95,000 cu ft is now being designed.

Along with enlarging their volume, considerable changes are being made in the blast furnace profiles. These changes are characterized by relative decreases of blast furnace height, narrowing of the furnace gorge and broadening of the hearth. The shaft angle of the furnace has decreased, and the belly angle increased.

Of some interest is the design of the largest blast furnace today, which has a useful volume of 60,600

cu ft. Practice has shown a blast furnace of this design to possess high efficiency and a low ratio of coke consumption.

The first 60,600-cu ft blast furnace was put in operation in September, 1958. It has a profile which is distinguished by a greater increase in the hearth and body diameter than in the furnace top diameter: the ratio of the top diameter to hearth diameter is 0.76, and to body diameter is 0.68 (blast furnaces with volumes of 45,000 and 48,500 cu ft possess a ratio of 0.79 and 0.70, correspondingly).

The experience gained during the one and a half year's operation of this furnace has shown that the indicated furnace profile improves charge passage and to allows for speeding up the melting process. Increasing the furnace shaft height to 58.5 ft has permitted better use of regenerative and heating energies of gas.

The 60,600-cu ft blast furnace has four stoves with a heating surface of 290,000 sq ft, this permits heating the air to 1800–1900 F. One air heater, at initial roof arch temperature of 2070 F, is capable of heating 124,000–130,000 cfm to a temperature of 1800 F for 2.0 to 2.5 hr. When three air heaters are operating in series, the fourth has time enough to heat up to the required temperature, consuming up to 1,240,000 cu ft of blast furnace gas per hr. High-capacity burners and fans permit combustion of this quantity of gas.

The roof arch and the air-heater checker top, which are lined with refractory brick, have permitted raising blast temperature to 2000 F.

Due to the more efficient blast furnace performance and the correspondingly lower thermal capacity of blast furnace gas, it became necessary to blend blast furnace gas with coke or natural gas for the stoves. This permits raising blast temperature to 2200 F. The refractory brickwork is capable of standing this temperature.

The blast is fed into the 60,600-cu ft blast furnace by a blower which has a capacity of 140,000 cfm at 56 psi. The blower is driven by a 17,000-kw turbine at a rotor speed of 3000 rpm.

Three months after the 60,600-cu ft blast furnace was put in blast, an investigation was conducted with the purpose of drawing up the material balances of blast furnace performance. Here are the results of this investigation:

Output capacity (tons per 24 hr)	2544
Input of materials (moist) in lb of material per ton of cast iron:	
Coke	1454
Agglomerate	3382.6
Iron ore	580.8
Manganese ore	117.0
Limestone	594.0
Share of agglomerate in the iron-ore burden, in per cent	171.4
Basicity of agglomerate ($CaO:SiO_2$)	1.0
Iron content in ore burden, per cent	49.3
Recalculated in units of nonfluxed agglomerate	55.1
Iron-ore ratio to coke, tons of ore per ton of coke	2.57
Recalculated in units of nonfluxed agglomerate	2.28
Coke, combustion intensity, tons per cu ft per 24 hr	0.0291
Slag yield, lb per ton of cast iron	1540
Dust yield, by balance, lb per ton	297.0
Blast parameters:	
Input, cfm	11.780
Temperature, F	1800
Humidity, grams per cu ft	1.2
Gas pressure in furnace top, psi	18.5
Furnace gas content, per cent	
CO_2	14.7
CO	27.6
H_2	1.6
Results of material balances:	
Dry-air input, cu ft per ton of cast iron	5886
Dry gas yield, cu ft per ton of cast iron	8055
Carbon consumption in furnace, total lb per ton	1140.6
Carbon burned by blast oxygen:	
Lb per ton	934.8
In per cent	82.0
Consumed for direct regeneration, lb per ton	205.8
In per cent	18.0
Degree of regeneration per M. A. Pavlov's method, in per cent	38
Participation in regeneration, per cent:	
Carbon monoxide, forming at tuyères	40.9
Hydrogen from blast moisture decomposition	69

Note should be made of the considerable participation of blast moisture hydrogen in the regenerative processes. Besides, the blast is enriched with oxygen due to the presence of oxygen in the moisture. This explains the fact that high temperature blast and enhanced, constant moisture is successfully employed at most of the blast furnaces in the USSR, since it cuts down coke input and intensifies the blast furnace process.

The efficiency attained on this blast furnace is not the limit. In recent time a ratio of 0.70 for the utilization of the blast furnace useful volume* has been reached on another identical blast furnace, which is equal to a daily output of 2700 net tons.

It should be stressed that there are blast furnaces in Russia with a volume of about 50,000 cu ft, that produce 2650 tons of cast iron a day each, but with a charge that consists of 100 per cent agglomerate and higher iron content.

Extensive use is being made of carbon blocks and high-aluminiferous brick for laying the hearth blocks and hearths of blast furnaces. The use of carbon refractories in lining the blast furnace hearth makes it possible to decreased hearth block erosion, provided the block is well cooled.

Air cooling of the hearth block has been employed

* Editor's Note: The coefficient of utilization of useful capacity is calculated by dividing the volume of useful capacity of the furnace (measured from the centerline of the iron notch to the bottom of the large bell in the open position) in cubic meters, by the daily output in metric tons, i.e., if the daily output is 1250 metric tons and the useful capacity is 1000 cu m, then the coefficient of utilization is 0.80.

since 1956. This is done with the aid of pipes laid in parallel bundles under the carbon blocks, through which cooling air is conveyed.

The hearth block of a blast furnace at the Dzerzhinsky works has the shape of a spherical sector both inside and outside. Such a shape provides for a more uniform heating of the hearth block and prevents the formation of cracks. At the initial stage of operation the shape of the hearth block resembles the condition it has after erosion. The hearth block is lined with carbon blocks. There are coolers between the lining and the jacket.

The blast furnace does not have the usual base; it is supported by pillars stationed on the foundation.

At present blast furnaces with evaporative cooling of different furnace elements are being tested. The USSR has been building such furnaces since 1957.

So-called single-lip teeming of cast iron has been introduced since 1956 at the Magnitogorsk Iron and Steel works with the purpose of facilitating the difficult operations involved in the preparation and the change of lining of blast furnace spouts. This has been effected by installing a throw-over spout and moving the ladles as they fill up.

Besides providing better labor conditions this system reduces the length of spouts and will subsequently, when fully developed, permit cutting down the length of casting beds when designing new blast furnace plants.

The Cherepovets Iron and Steel works which was built after the war has a blast furnace plant of a rather original design. The plant actually has no stockyard, the raw material is fed into the blast furnace hoppers by conveyers. The plant operates on 100 per cent agglomerate produced from an ore concentrate of constant quality and delivered always from the same ore deposit. The fact that the plant has been working on a strictly constant ore component fluxed agglomerate, on good coke from a constant concentrated coal charge, on a furnace top gas pressure raised to 27 psi and at a blast temperature of 1900 F has permitted obtaining on 36,000-cu ft blast furnaces a ratio of blast furnace useful volume utilization of 0.58 in the course of a month (about 57,600 net tons).

On two blast furnaces at the Magnitogorsk Iron and Steel works, where the hoppers had been fitted with hand-operated disk bolts, the feed of raw material by means of scale cars has been replaced with conveyer feed. The blast furnace plant of the works has also obtained a very good ratio of 0.605 in the utilization of the blast furnace useful volume.

Great attention has been paid in recent time to automation in blast furnace production, particularly for: skip-hoist and furnace-top equipment control; screen sizing, weighing, loading into skips of coke; control of blast temperature and humidity and gas combustion in air heaters; and adjustment of gas pressure in the furnace throat.

Intensive work is under way to design a circuit and instruments for automatic control of the blast furnace processes. It is intended to use computers for this purpose. The difficulty is that the physical phenomena in the blast furnace process are so complicated that all attempts to reflect them by a corresponding system of equations have so far ended in failure. Such a system is the main thing in the application of a single cycling machine. That is why a series of local cyclers for the different stages of the blast furnace process are to be constructed to facilitate the job. Hereafter they may be joined into a common control circuit with a single co-ordinating computer.

The USSR has attained high blast furnace efficiency with low coke input. This is due to an increase in the output of agglomerate, particularly of fluxed agglomerate, to neutralization of ore and cooking coals, the operation of blast furnaces at high top pressure, the use of high temperature blast with constant humidity, the application of natural gas and oxygen-enriched blast and to more intensive blast furnace performance.

The share of beneficiated burden used in the blast furnace charge in the USSR is at present the biggest in the world, with the exception of Sweden, and is about 80 per cent.

The 1960 plan provides for the output of 80,000,000 tons of fluxed agglomerate, this being almost the entire agglomerate produced.

At the Magnitogorsk Iron and Steel works the basicity of agglomerate (the ratio of calcium oxide to silicic acid) is 1.4. With such a basicity but a small quantity of raw limestone is charged into the blast furnace, this being done when it is necessary for improving the state of slag during smelting.

No raw limestone is employed at the Cherepovets works and other plants that operate fully on agglomerate or with small additions of ore.

Fluxed agglomerate possesses a much higher regenerative capacity than ordinary agglomerate, which is due to the lower content of iron silicates in the agglomerate. Besides, the input of heat for the decomposition of limestone is in this case shifted from the blast furnace to the agglomerating plant, and this facilitates the work of the blast furnace and cuts down coke consumption.

When blast furnaces are operated with fluxed agglomerate, their productivity is raised by 7 to 12 per cent depending on basicity and other conditions, and coke consumption decreases by three to five per cent. Transition to operation with high-basicity agglomerate is the main target of Soviet metallurgists in the current 7-year plan period.

Research has shown that the output capacity of blast furnaces working on 100 per cent beneficiated burden instead of ore increases about 20 to 25 per cent, coke consumption decreases by 20 to 25 per cent and flue dust comes down by 40 per cent.

High top pressure has served as an important factor in intensifying blast furnace performance. There were 70 blast furnaces, thus operating in the USSR at the beginning of 1959, and they produced 82 per cent of the total cast iron. Excessive gas pressure is maintained at most furnaces within the range of 9 to 12 psi; in some of them at 15 to 22 psi; and one furnace operates constantly with an overpressure of 27 psi.

It has been established that an increased top pressure of 10 psi (overpressure) raises blast furnace efficiency by five to eight per cent, cuts down coke consumption by 1.5 per cent, reduces flue dust by 30 to 50 per cent and facilitates considerably the purification of blast furnace gas. Operation with high top pressure contributes to more uniform blast furnace

performance, better distribution of gas throughout the furnace section and consequently to a better utilization of heat and chemical energy.

High-temperature blast with constant humidity is extensively employed. It was first introduced on a wide scale at the Kuznetsk Iron and Steel works in 1949.

Thus, the economic expediency of employing blast with increased but constant humidity was proved practically and theoretically. A simple method for adding steam to the blast and an instrument for automatic maintenance of constant humidity were developed at the same works.

Moisture enriches the blast with oxygen by 0.63 per cent per 0.3 gram of moisture per cu ft injected into the blast, and that this speeds the blast furnace process. Being a stronger reducer than carbon monoxide, the hydrogen obtained from the dissociation of steam also intensifies the process. Prior to employing moist blast the blast temperature was 900 to 1000 F. Many thought that the raising of temperature and the maintenance of uniform furnace performance could be effected only by improving raw material quality. With the application of moist blasting at constant humidity the temperature of the blast rose to 1460 to 1740 F.

In order to compensate for the heat used up to dissociate steam, it is essential to raise the blast temperature 16 F per each 0.03 gram of additional moisture in a cu ft of air. If this is not done, the furnace will cool when the steam supply is increased and the input of coke will have to be increased. At most plants air humidity is maintained on the level of approximately 0.7 grams per cu ft, under conditions with a mean annual natural blast humidity of 0.2 gram per cu ft.

High-temperature blast of constant humidity (0.7 gram per cu ft) increases cast-iron output by approximately seven per cent and cuts down coke consumption by no less than two per cent, as compared with conventional blast.

The cost of cast iron produced with moist blast does not increase since the expenses of steam and higher air heat are compensated by lower coke input and lower general expenses.

Of all the blast furnaces in the USSR, 94 per cent operate on constant-humidity blast. There is a tendency at some plants today to lower blast humidity and to raise temperature to a maximum. The additional heat brought in by high-temperature blast goes directly into the process, thus permitting a cut in the amount of coke required. For instance the Cherepovets works which operates on fluxed agglomerate with furnace-top pressures up to 27 psi, has reached a mean monthly blast temperature of 1900 F with constant blast humidity of 0.21 grams per cu ft.

At the blast furnaces where natural gas is blown in and thus additional heat is required for dissociating methane, the humidity of the blast is also lowered.

Natural gas has been found to reduce coke input by 10 to 15 per cent and to cut down the production price of cast iron by approximately ten per cent. If natural gas is employed in combination with an oxygen-enriched blast, the effect is much greater still: the saving of coke reaches 20 per cent, blast furnace efficiency increases by five to ten per cent, and the cost of cast iron comes down correspondingly.

Over 50 blast furnaces are to be shifted over to operate on natural gas by the end of the 7-year period, and 35 to 40 per cent of all cast iron is to be produced with the use of oxygen.

The production of cast iron with a low-manganese content is widely practiced in the USSR.

The processing of low-manganese cast iron in open hearth furnaces has been found to increase the input of ferromanganese in steel deoxidation by one to two lb per ton. Ultimately, however, the transition to low-manganese cast iron yields considerable economic effect.

The engineering progress in blast furnace production in Russia is indicated by the following table.

TABLE I
Blast Furnace Production

Indices	Years			
			1959	
	1940	1950	Absolute	Changes as compared to 1940
Ratio of blast furnace useful volume utilization, cu ft 24 hrs per ton	1.19	0.98	0.771	+54.3
Current idle standing	4.6	1.8	1.1	...
Cast-iron output per worker of blast furnace shops, tons per year	1061	1416	2678	A 2.5-fold increase
Coke input, lb per ton of open hearth pig iron	1946	1842	1512	Reduction by 23.4 per cent
Furnace-top dust, lb per ton of cast iron	716 (1938)	500 (1951)	234 (1958)	A 3.1-fold decrease

The ratio of the utilization of blast furnace useful volume in the USSR is believed higher than that in the U. S. and other countries.

STEELMAKING

Steel output in Russia is divided among the methods of production as follows:

	Tons	*per cent*
Open hearth furnace output	57,000,000	85.4
Converter output	4,050,000	6.0
Electric furnace output	5,650,000	8.6
Total	60,000,000	100.0

As regards methods of production there is no important distinction between steel output in the USSR and that in the U. S. Subsequently, however, with a general increase in steel output the share of converter steel will grow substantially and reach a quarter of the total steel output.

The more rapid development of the converter method promises a number of great advantages. The construction of converter plants is 30 to 40 per cent cheaper than that of open hearth furnace plants. At the same time the service costs are approximately 20 per cent lower, there being no expenses on fuel with the converter method. The quality of converter steel produced

with technically pure oxygen is in no way inferior to open hearth steel, while converter-made sheet steel which goes into stamping with extrusion is even of better quality. Converters with 275-net ton capacity and using oxygen application are to be built.

There will also be a considerable growth of electric steel production. Its share in the total steel output will increase to 12 to 14 per cent. However, the open hearth furnace will remain the dominating process.

Open hearth steel production in the USSR has been developing and will continue to develop in the future chiefly due to the construction of big furnaces. This is one of the basic factors in the engineering progress of open hearth production. The 7-year plan provides for the construction of large open hearth furnaces only. Today the maximum capacity of Soviet open hearth furnaces is 550 tons. Furnaces of 660-ton capacity are to be built in 1960. An 880-ton open hearth furnace with 2-ladle teeming is being designed; its capacity can be increased to 1000 tons.

Open hearth furnaces in Russia were enlarged mostly by increasing the bath depth and not by enlarging the hearth area. The furnace's working space was enlarged, its heat capacity raised, and this led to the increase of the furnace roof arch, to 118 to 130 in. in the largest furnaces.

The roof arches in over 90 per cent of all the open hearth furnaces of the Soviet iron and steel industry today are made of chrome-magnesite or magnesite-chrome heat-resistant brick. This has increased the service life of open hearth furnace roof arches between repairs more than 2.5 fold as compared with that of dinas brick (95 per cent silica) roof arches. The result is that the idle time of open hearth furnaces has been reduced by three to four per cent and their output capacities increased by seven to 12 per cent. In some furnaces 700 to 800 and even 1000 heats are obtained without overhauling the chrome-magnesite roof arches.

It should be stressed that the advantages offered by the use of basic heat-resistant brick for furnace roof arches are not utilized fully. This is due to the fact that the elements of the furnace bottom (checkers, slag pockets, regenerator partitions) which are laid of dinas acid brick have a shorter service life than does the roof arch. In such cases it is only the bottom part of the furnace that is subjected to rebuild, the roof arch being left as it is. To prevent the roof arch from destruction due to cooling, it is warmed during the rebuild with coke gas which is supplied via pipes to the space under the arch.

Work is under way in the Soviet Union to find a brick for the furnace bottom part that would have greater refractoriness and slag stability. Forsterite brick has been successfully employed for the upper rows of the regenerator checkerwork, and good results have been obtained from employing chrome-magnesite, duniteforsterite and dolomite brick in the upper checkerwork rows.

The application of these kinds of brick has permitted raising the checker temperature to 2500 to 2700 F, instead of the 2250 F permissible before. Smelting time was reduced by almost 20 per cent, and the input of fuel per ton of steel came down by 15 per cent.

A basically new system of evaporative open hearth furnace cooling has been successfully employed in recent years. It utilizes the latent heat of steam generation by substituting a steam water mixture for the normally used cold water. The steam obtained from such cooling is used mainly for heating purposes. The new cooling system requires chemically purified water.

At present 50 per cent of all the open hearth furnaces have been shifted over to evaporative cooling. No new furnace is being built without such a cooling system.

There is an extensive practice of fitting open hearth furnaces with waste heat boilers which utilize the heat of exhaust furnace gases for steam generation. The use of such boilers helps to recover over one half of the heat carried off by flue gases; moreover, due to a more intense draft the heat capacity of open hearth furnaces is increased and their efficiency raised.

A project is being developed at present for uniting into a single system the recovery boilers and the evaporative cooling system so as to have a uniform and higher steam pressure in the general forced circulation system.

In Russia oxygen is chiefly used in the working chamber where it is fed through the furnace top to intensify the fuel combustion process. In a few open hearth furnaces oxygen is fed into the furnace for the direct oxidation of the bath. However, the latter method leads to a faster wear of the furnace and to greater losses of iron, the saving on fuel not compensating the expenses for oxygen. Practice has shown that the combination of the two methods of oxygen supply, into the bath and into the burner, could result in enhancing the efficiency of the furnaces and cutting down fuel consumption.

A project for the construction of a unit capable of producing 1,235,500 cu ft of oxygen per hr is being developed at present to cut down the cost of oxygen, which is still quite high.

Some plants supply compressed air into the open hearth furnace. This raises the efficiency of open hearth furnace performance by up to eight per cent.

The rapid growth of natural gas output in the USSR had led to the large-scale use of natural gas as fuel for open hearth furnaces. Natural gas is used as an additive to coke and furnace gas or mazut in certain proportions. Some plants are developing a system of steel smelting on natural gas alone, which will materially simplify the design of open hearth furnaces.

There is a great future for the continuous casting of steel, and there are a large number of continuous casting installations at the country's steel plants. At present 2-pass and 4-pass installations operate with high efficiency. They are used for teeming big melts of open hearth and electric furnaces. These installations are used in the production of wide slabs and a variety of square section billets. The slabs produced have such good surfaces that there is no need to clean and dress them prior to rolling. Larger installations of this type are to be put in operation in the near future.

The 7-year plan envisions large scale introduction of continuous casting. Its advantage is not only in the fact that it increases the output of rolled metal by no less than eight per cent, but when this method is fully developed, there may be no need to build blooming and slabbing mills.

Most of the open hearth furnaces are equipped with instruments for controlling the individual elements of the thermal cycle. Some plants have elaborated and introduced new systems for the all-round automation of the open hearth furnace thermal cycle with the aid of computers. The use of such automation on a 400-ton furnace has shown that it may yield 1.4 to 1.6 tons of steel per sq ft of hearth area per 24 hr, while a nonautomated furnace of the same capacity yields 0.92 to 1.2 tons correspondingly.

ROLLED METAL PRODUCTION

The 7-year plan envisions the production of 71,000,000 to 77,000,000 tons of rolled steel in 1965, which is 53 to 63 per cent more than was put out in 1958. The seven years are to see the construction and commissioning of 82 new metal rolling and pipe mills. They will have an aggregate capacity of 25,000,000 to 32,000,000 tons.

There will be considerable changes and enlargement of the rolled metal assortment, providing for a sharp increase of the share of sheet metal and pipes.

The variety of rolled steel has in recent years been considerably enlarged. The task facing the industry today is the further enlargement of rolled stock produced. There is to be more extensive application of heat treatment of steel: of low-alloy steel, bent sections, coated metal, electric metal, stainless steel sheet metal, etc.

The engineering level of the USSR's rolled metal industry has in recent years been raised considerably due to the commissioning of a number of new modern mills and the modernization of the old ones. Nevertheless the engineering level of this branch is lower than it is in blast furnace and open hearth furnace production.

All blooming mills operating in the USSR are of the 2-high reversing type with roll diameters of 32½ to 47 in. There are two 2-stand blooming mills with tandem layout of the stands.

A number of technical measures were carried out at Soviet plants with the purpose of raising blooming mill efficiency. These include: increase of ingot and billet weight, improvement of metal gaging, increasing the draft at each pass, raising rolling speeds and improvement of equipment repairs. At the Magnitogorsk and Kuznetsk Iron and Steel works these practices have doubled the capacity of the blooming mills as compared with the design capacity. In other countries most of the 2-high reversing blooming mills operate with a capacity of 1,000,000 to 2,000,000 tons of ingots a year. We know of but two cases of a blooming mill and a slabbing mill in the U. S. and Britain having a design capacity of some 3,000,000 tons per year. The blooming mills at the Kuznetsk and Magnitogorsk works have capacities that are much higher than that.

Some blooming mills in the USSR have automatic control of the main mechanisms, i.e., pressure devices, receiving, flattening and working roll tables and other units.

The output capacities of blooming and slabbing mills are to be raised still higher. It is planned to increase the roll diameters to 51 in. and to enlarge ingot weight. The slabbing mills will roll 33-ton ingots into slabs up to 79-in. wide.

There are six rail and structural steel mills of the tandem type at the USSR's iron and steel works. Note should be made of the rail and structural steel shops at the Nizhni-Tagil Iron and Steel works and the Azovstal plant. They are the most powerful in Europe and unequalled as to the degree of mechanization. The rail and structural steel mill at the Nizhni-Tagil works, which was built at the Ural Heavy Machinebuilding plant, is provided with five continuous furnaces for the isothermal quenching of rails. All rail-finishing operations on this mill are fully automated. The output of heavy rails, 130 to 150 lb per yd and 82-ft long, has been started and is to be extended.

As to heavy-section rolling mills, they do not differ materially from those in other countries, including the U. S. with regard to the type and specifications of their basic equipment, mechanization degree and rolling technologies.

Among the small-section rolling mills in the USSR there are both continuous and semi-continuous mills in operation. Two of the continuous mills operate with two strands.

Rolled wire is chiefly made on continuous mills although there still are mills with a tandem stand layout. A 2-strand small-section rolling mill (the "250") and a 4-strand wire mill with a 6000-fpm rolling speed and a 725-lb bale weight have been put in commission at the Krivoy-Rog plant.

Three of the latest plate mills for the production of thick hot-rolled steel plates merit attention. They are the "2800" mills installed in recent years. These installations consist of 2-stand mills with 4-high finishing stands. They have an output capacity of approximately 1,000,000 tons per year.

A fully mechanized and automated continuous mill (the "2500") for making hot-rolled sheets will be put in operation in the near future. It has been constructed at the Novo-Kramatorsk plant. This mill will roll a 0.06 to 0.47-in. thick and 39 to 93-in. wide strip from slabs 4½ to 6-in. thick and 6 to 18-ft long. This wide-strip continuous mill will handle both carbon and alloy steel. The final finish stand will have a rolling speed of up to 2400 fpm. Slabs can be fed to the furnaces directly from the slabbing mill by roller train, and delivered from the storage by crane. The slabs are heated in 3-zone fired recuperative furnaces with butt-end discharge. The slabs are put into the furnace with the aid of rams. The width of the working space in the furnace is 20 ft. The project provides for space being reserved in the shop for a fifth furnace.

The heated slabs discharged from the furnace pass after a small roughing pass through a scalebreaker. The scale is crushed and then beaten off from the top and bottom by water under high pressure. Hereafter the slabs pass on to the widening stand. The subsequent rolling takes place in three all-purpose roughing stands, where the slabs are roughed simultaneously throughout their thickness and edges. Then the strip is transported to the finishing group of stands and after passing through a scalebreaker is rolled on six finishing stands.

After rolling the strip is wound into coils weighing not more than 11 tons or cut on flying shears into 10 to 30-ft sheets, transported to a packaging device and laid in bundles weighing up to 22 tons.

The "2500" mill consists of ten working stands, two scalebreakers, flying shears for cutting off the strip

ends and cutting the strips into measured lengths, three coilers, a packaging device for the sheets, roll handling device and loading mechanisms. The working stands are of 4-high, while the scalebreakers are 2-high. The work rolls are mounted in anti-friction bearings, the backup rolls in oil-flooded sleeve bearings.

Planetary mills for sheet steel production are to be built and one of these mills is now being completed. It is planned to combine a planetary mill doing 90 per cent roughing in one pass with a continuous casting unit. The rolling mill of the near future may be pictured as consisting of continuous casting plants followed by a planetary mill and one or two continuous rolling mills.

New drives for rolling mills are being designed with the purpose of increasing drafts and raising rolling speeds. Additional rolling stands are being installed, the weight of ingots, slabs and billets are being increased and more rational roll passes designed. The durability of rolls is being enhanced through their automatic welding, and rolls are being made of high-strength cast iron with hardened grooves and surface.

The 7-year plan provides for a large development of the chemical, power-engineering, oil and gas industries. All these branches will require large quantities of steel pipe. That is why, though the general increase in rolled stock production will amount to 53 to 63 per cent, the output of pipes is to be more than doubled.

The share of welded pipes will increase and be more than 50 per cent of all the pipes produced. Especially extensive is the development of submerged arc welding. This method will, among others, be widely employed in the production of high-pressure gas and oil-pipeline tubes with diameters of 16.8 to 48 in. Extensive use will also be made of such processes as induction welding, as well as argon-arc and atomic-hydrogen welding of pipes. The last pipe welding methods are especially advantageous for the manufacture of pipes from high-alloy steels, including stainless steel pipes.

Soviet plants will produce thin-walled seamless pipes of large diameters, bimetal pipes, as well as pipes with different kind of metallic and nonmetallic coatings, including enamel-coated and plastic-lined pipes of varying section for a wide range of jobs.

Of great importance is the manufacture of extra-thin-walled pipes employed in various branches of modern engineering. It has been established that the best way for making such pipes is manufacturing them on roller mills. Such mills were first designed and built in Russia and a great number of them are now operating at Soviet enterprises. They are used for cold rolling of pipes with 0.3 to 4½-in. diameters and up to 18-micron wall thickness. The same type mills can serve to produce pipes with greater diameters 15½ to 27½ in.

Drawing on the principles underlying the design of the above-mentioned cold pipe rolling mill, the design on a small-roller planetary mill has been evolved. It differs from similar mills used abroad in that it is adapted to rolling pipes on the mandrel and not from sheets or strips. A considerable degree of roughing within one pass is effected due to the great number of rolls working on the metal from three sides. Thus, pipes with a diameter of 1.2 in. and a thickness of 0.012 in. are produced from a stainless steel pipe blank of 1.4-in. diameter and 0.06-in. wall thickness within a single passage in cold state. Such a mill is distinguished for an efficiency that is five to eight times greater than that of the existing ones. This alone provides sufficient grounds to believe that such mills are bound to find an extensive field of application both in the cold and hot-rolling of pipes.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Test Stand Evaluation of Oil-Film

by SAMUEL S. RICKLEY
Chief Engineer
Morgoil Bearing Dept.
and NORMAN A. WILSON
Manager of Research
Morgan Construction Co.
Worcester, Mass.

. . . . the use of higher and higher speeds and loads has stimulated full size oil-film bearing investigations and made further operating characteristic data available . . . .

BY 1920 the continuous mill design for merchant, bar and rod mills was well accepted and the idea was spreading to hot and cold-rolling of sheet and strip steel. The continuous concept introduced many problems including that of proper roll neck bearings. The rolls turned faster, the loads were higher and the duration of the load was much longer. In addition, since the continuous mill represented such a large capital investment, it was mandatory that all components including the bearings be extremely reliable.

Therefore, at that time the requirements for a roll neck bearing were that it should have:

1. High continuous load capacity.
2. Low coefficient of friction.
3. A design permitting a large, strong roll neck.
4. Minimum wear.
5. Simplicity and ease of maintenance.
6. A design permitting quick and easy interchangeability from roll to roll.
7. Stability of operation.
8. Precision design and manufacture.

The success of the precision oil-film bearing in meeting these requirements can best be illustrated by its wide usage throughout the world. Mills using the oil-film bearing range from blooming and slabbing mills to high-speed 6-stand tandem cold mills in the steel industry, and from hot mills to high-speed foil mills in the nonferrous industry.

In these days when tremendous research projects are carried out and elaborate tests are performed before a new product is launched, it is interesting to note that this oil-film bearing was invented and the design developed with research and test facilities, which would be meager by modern standards. The basic bearing design was derived from the theory of hydrodynamic bearings and the two basic design parameters were ZN/P (absolute viscosity times rpm, divided by unit pressure) and PV (unit pressure times velocity). The first parameter defined the limits for having full oil-film separation of bearing journal and bushing; the second parameter defined what was thought to be the top limit of operation.

Actually a great deal of time and money has been spent on research and tests in connection with oil-film bearings by many companies, universities and the U. S. Navy. However, due to practical requirements, most of the research has been confined to small bearings with journal diameters less than two in. or if larger journals were used the speed was limited.

Due to tremendous loads, bearing size, speed, power requirements and method of loading, the best way to test a roll neck bearing is in a rolling mill. Due to the time involved and the consideration of production, these tests have been necessarily of short duration and confined to pressure tests for rolling specific material or schedules, oil flow and temperature tests and material or design evaluation. These tests have been very helpful in solving the specific question at the time, but they also emphasized the need and the desirability of

Roll Neck Bearings

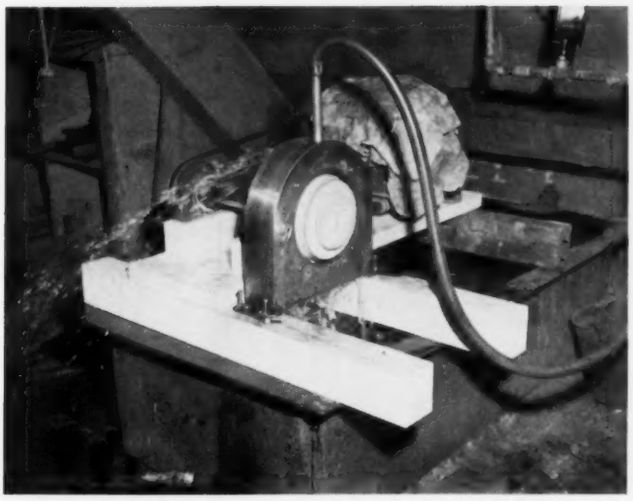


Figure 1—A testing device was made to test seal efficiency.

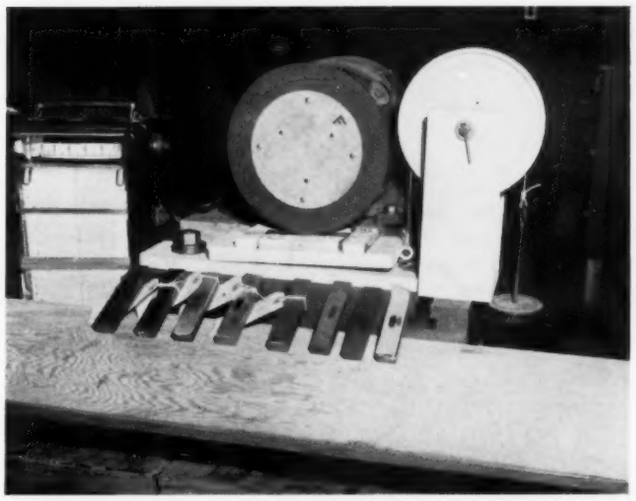


Figure 2—Various coatings applied to ductile-iron bars were subjected to high-speed rubbing tests.

further testing of bearings under laboratory conditions. This point is well illustrated by a neck seal recently introduced to rolling mill builders and operators. The basic design of the seal was conceived in the engineering dept. and was given its first field test in the initial design stage at a Canadian steel plant on a 25 and 49 x 56-in., 4-high reversing hot steckel mill. A set of seals was supplied and in due course, they reported excellent sealing efficiency and little wear. This test proved the seal on a reversing hot mill having a speed of 720 to 1800 fpm, or a backup roll bearing rpm of 58 to 145, and using water as roll coolant.

Before the seal could be released for general use, two rather important questions had to be answered: how would the seal perform at 6500-fpm mill speed and 2500-rpm roll speed as encountered in a rod mill finishing train; and how would the seal material react at high rubbing speeds and without lubrication as might be encountered in a temper mill?

To test the efficiency of the interlocking laybrinth, a simple machine was built with a mock-up of the labyrinth and roll neck, see Figure 1. The roll body would be to the left, and the roll neck and bearing casing to the right. The metal housing contains the seal elements and forms a guard to concentrate the water on the seal. This machine tested the seal from 0 to 2000 rpm with a concentrated jet of water flowing at the rate of ten gpm.

Under these conditions there was absolutely no visible water or mist on the stub roll neck side of the seal. However, note the water dropping out of the bottom and being thrown by the roll barrel.

To test the seal at high rubbing speeds and without lubrication, the machine illustrated on Figure 2 was built. This simple test machine was driven by a 1-hp, 1800-rpm motor. The rotating disk was made of the same synthetic rubber compound that is used in the seal element. The disks used had a 9 $\frac{9}{16}$-in. diameter which based on an rpm of 1750, gave a rubbing speed of about 4400 fpm. A test load of three lb was used which, based on the scar area, gave a loading of about 35 psi.

In the actual seal the static element is a ductile-iron ring. In the test machine ductile-iron bars coated with various materials were used. A recording wattmeter was also connected to the motor. With this setup, which coating had the longest life and also the relative friction for the various materials tested could be determined. From left to right the various coatings tested (Figure 2) were:

	Friction, kw	*Life, hr*
Bare ductile iron	0.5	....
Chrome plate, 0.0005 in.	0.45	5½
Copper plate, 0.002 in.	0.6	24
Cadmium plate, 0.0015 in.	0.6	2
Chrome on flash copper plate, 0.003 in.	0.55	24
Both sides coated:		
Acrylic, 0.004 in.	Over 2	Less than 1 min
Teflon, 0.0015 in.	Over 2	Less than 1 min
Epoxy, 0.0004 in.	2	Less than 1 min
Teflon, 0.015 in.	2 to 0.8 before failure	5 min
In the machine:		
Chrome, 0.0025	0.45	60

The life of the various coatings tested varied from

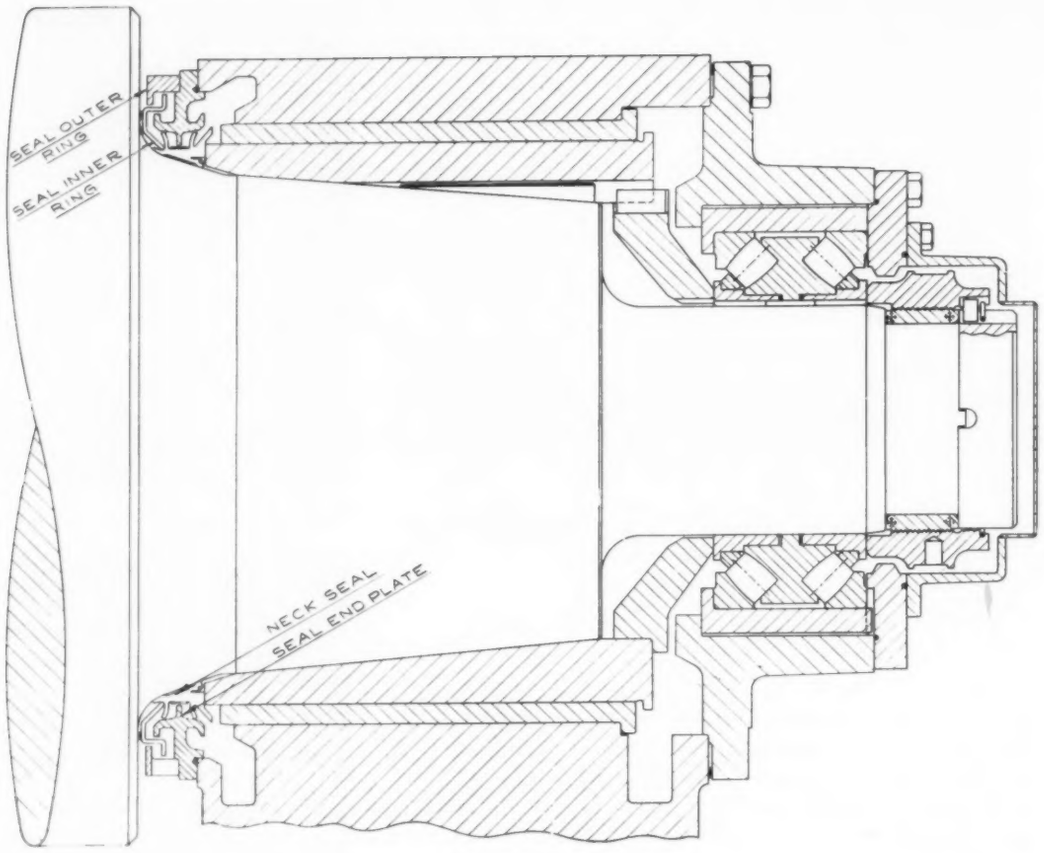


Figure 3—The final seal design was determined after considerable testing.

less than one min up to 60 hr, and the relative friction ranged from 450 to over 2000 watts. In all cases where the coating lasted an appreciable length of time, it was noted that the friction was high for the first two or three min and then reduced to its final normal level. It was found that any lubricant introduced to the rubbing parts immediately raised the friction, but not to any serious degree. These two test machines which have been briefly described, merely illustrate how design improvements have been tested. Figure 3 illustrates the final neck seal design.

However, much more elaborate equipment is needed to test and evaluate a complete bearing. Slightly over a year ago the opportunity of using a test machine capable of testing an oil-film bearing was presented to us by the Aluminum Co. of America, who for many years have been engaged in the testing and evaluation of journal bearings. Heretofore all their test facilities were confined to small bearings of the type used for internal combustion engines, air compressors, etc.

Alcoa advised that they were designing and planning to build a general purpose test machine. It was their intention to make this machine available to their customers in order to evaluate and develop their bearings. This machine was designed to load a test bearing up to 180,000 lb and had a mechanically variable speed drive having a speed range of 350 to 1400 rpm. They offered to test our bearing first, if a size was selected that could be worked into their machine.

The following desirable objectives of a bearing test machine were set up:

1. The test bearing should be a full sized bearing.
2. The test bearing should be mounted and loaded in the same manner as encountered in a rolling mill.
3. The test bearing should be loaded as much as 200 per cent of rated capacity when desired.
4. The test bearing speeds should be similar to those used in rolling mills.
5. The test bearing instrumentation should be such that load, speed, friction, temperature and oil flow could be measured and recorded.

With the above objectives in mind, the 9½-in., 70 series bearing, which has a rating of 106,000 lb was selected. This bearing incidentally is a bearing commonly used on rod mill finishing trains operating at speeds up to 2500 rpm. A typical section drawing of the bearing was submitted along with a request for more information concerning the design of the test machine.

Figure 4 shows the test shaft. Note that the main and auxiliary shaft bearings have been mounted in typical rolling mill fashion on hardened rocker plates to permit alinement of the bearings for shaft deflection. The geometry of this design is such that with the test bearing carrying the maximum test machine load of 180,000 lb the main bearing would be loaded 270,000 lb, and the auxiliary bearing 90,000 lb. The installed main roller bearing has a rated capacity of 283,000 lb at 500 rpm and 3000-hr minimum life. The auxiliary bearing is rated at 87,000 lb on the same basis.

The 9½-in. test bearing is top loaded through a hydrostatic breaker block so that friction characteristics of the bearing can be measured. The mounting and loading of the oil-film test bearing is similar to that of a top bearing in a rolling mill. The usual practice for oil-film bearings in a rolling mill is to design the bearing on

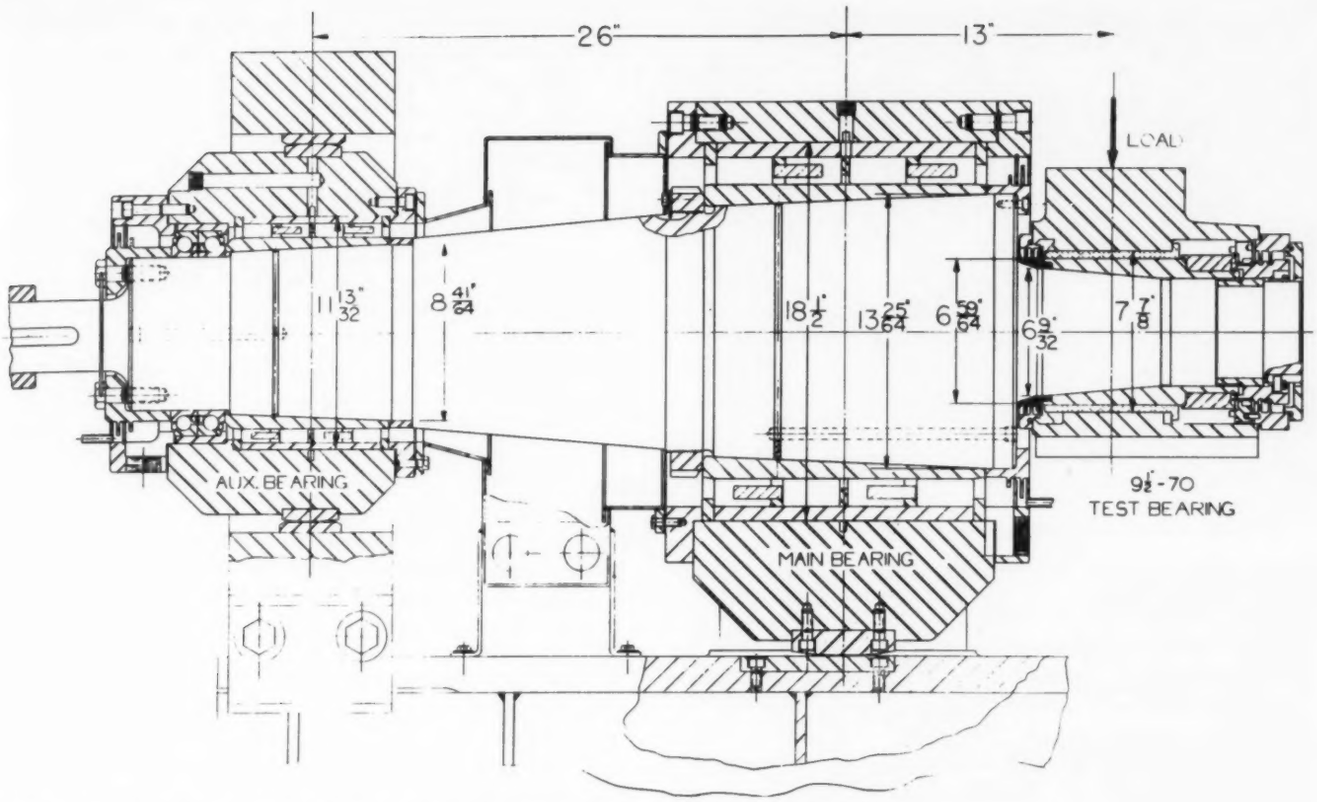


Figure 4—The test machine design was based on a test bearing load of 180,000 lb.

one side with a thrust unit (flat, ball or roller) and the bearing on the other side is free-floating in the axial direction. The floating design was selected so that the test results would not be affected by the thrust bearing performance.

The test machine is driven by a variable-voltage, d-c drive, rated at 40 hp, 0–1100–2200 rpm. With the mechanical and electrical features of the machine fixed, an attempt was made to predict the power and torque requirements of the oil-film test bearing based on earlier experiments.

Figure 5 shows the theoretical power and torque of the test bearing operating from 20 to 2200 rpm. This was based on the assumption of using an oil having a viscosity of 2600 SSU for the speed range of 20 to 200 rpm, and an oil with a viscosity of 200 SSU for the speed range of 400 to 2200 rpm. Note that the 2600-SSU oil curve is shown only up to 200 rpm, which is

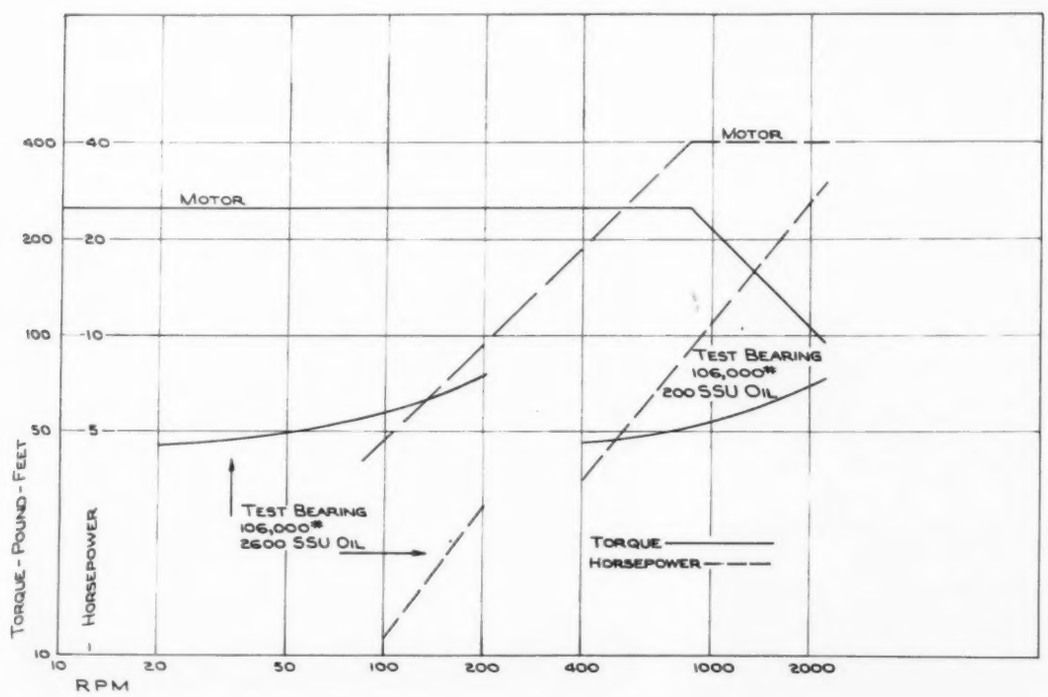


Figure 5—Theoretical curves were drawn assuming the use of two different oil viscosities.

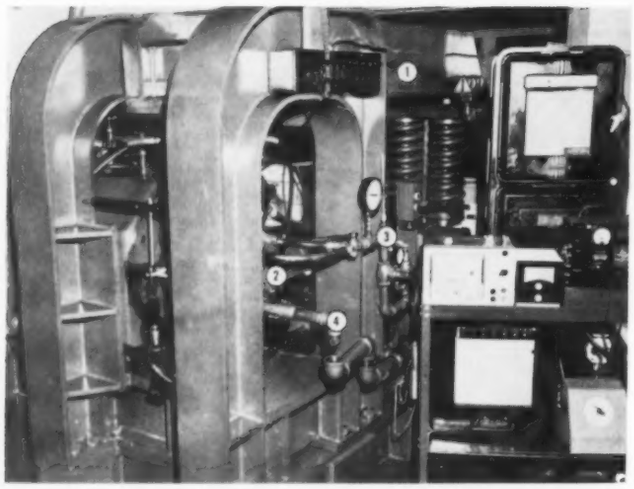


Figure 6—The test machine instrumentation was carefully checked to develop reliability and repeatability.

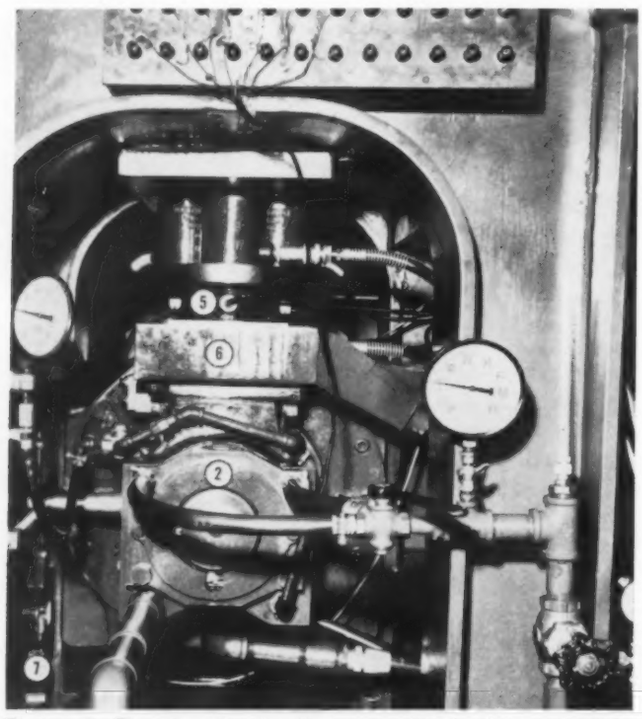
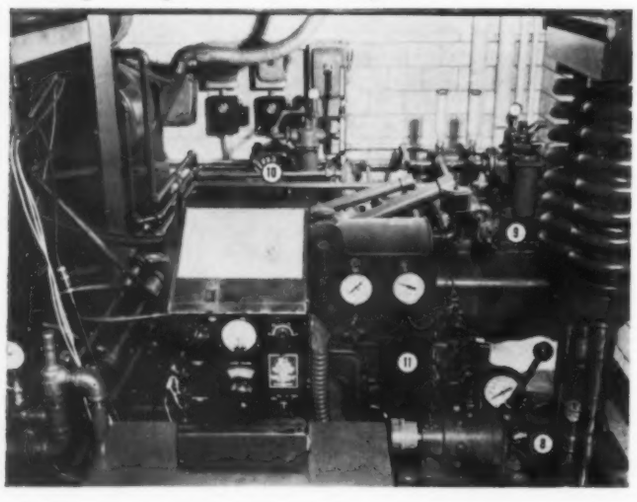


Figure 7—Test bearing loading was closely determined by strain gages.

Figure 8—The bearing was loaded by a hydraulic jack, working through a fulcrum arrangement.



about the normal design limits. What happened when this bearing was operated at much higher speeds with this heavy oil will be discussed later.

Figure 5 also shows the torque and horsepower curves of the d-c electric drive. At high speed the torque and horsepower requirements of the test bearing approach the torque and horsepower capacities of the drive. Since this graph was based on 100 per cent loading and only considers friction of the test bearing and neglects the friction of the shaft support bearings, it was realized that the testing would be somewhat limited at high speeds and high load. In actual operation the drag of the anti-friction shaft bearings was such that the top speed of the machine without a test bearing or load was 1700 rpm. With the 9½-in. test bearing loaded to 140,000 lb, or 133 per cent of its rated capacity, the top speed of the machine was about 1100 rpm.

The test bearing and the machine bearings are lubricated by separate circulating oil systems. To lubricate the two roller bearings and the ball thrust bearing of the test machine shaft, the manufacturer recommended a 15-gpm system using a straight mineral oil with a viscosity of 600 SSU.

The maximum oil requirement for the 9½-in. test bearing at speeds up to 2200 rpm, as figured in the usual manner, is 2.2 gpm. The test program contemplated evaluating the effects of increased oil flow. A lubricating system, for the test bearing, with a capacity of 5 gpm was installed. Thus more than two times the usual oil requirement was available. Figure 6 shows the complete test machine.

1. Load arm.
2. Test bearing.
3. Oil supply to test bearing.
4. Oil drain from test bearing.

Figure 7 is a close-up view of the test bearing:

2. Test bearing.
5. Load cell—for bearing load.
6. Hydrostatic breaker block.
7. Load cell—for bearing friction.

Figure 8 shows the loading cylinder and the various lubricating systems:

8. Load jack and hand pump.

Figure 9—Bearing speed at higher loads was limited by the motor drive horsepower.

9. Test bearing lubricating system.
10. Roller bearing lubricating system.
11. High pressure system for hydrostatic block.

Figure 9 shows the test machine drive:

2. Test bearing.
7. Load cell—for bearing friction.
12. Main shaft bearing.
13. Auxiliary shaft bearing.
14. The 40-hp d-c drive motor.

Some of the results obtained to date from the research program will be related to operating conditions insofar as possible.

This machine would have been unique if it had gone into operation without any difficulties. However, like most new testing equipment, this machine required considerable time to determine its operating characteristics, the accuracy and reliability of the instrumentation, and to establish the correct test procedure. It was important to spend the time necessary to complete this activity in order to insure confidence in the accuracy of the data and repeatability under identical test conditions.

As noted earlier, the research program which led to the original development of a precision oil-film roll neck bearing 30 years ago, though extensive, was not elaborately instrumented by modern standards, and was directed primarily to the achievement of hydrodynamic lubrication at the loads and speeds then common in rolling mill practice. Subsequent successful performance of these bearings in service confirmed that the early research results had been achieved, and subsequent field tests through the cooperation of numerous operating companies have led to useful improvements and refinements. However, determination of operating characteristics under controlled conditions comparable to those found in mill equipment had not been studied experimentally in oil-film bearings of this size, and this became a primary objective of the research program.

For the initial series of test, three 9½-in. bearings were used, two with steel-backed babbitt bushings and one with a solid aluminum bushing, designated as bearings A, B and C respectively in Table I.

Oil flow and oil temperature were of immediate interest, since these variables are easily measured in the field and provide a convenient means of anticipating and analyzing service problems. In most bearing investigations of this type, it is general practice to measure bushing temperature by means of thermocouples or similar devices in order to define completely the bearing characteristics. Previous field test experience showed that thermocouples, which are located approximately 0.015 in. below the bushing surface, have occasionally been the cause of bearing failures. For this reason, thermocouples were omitted from this series of tests.

TABLE I
Dimensions of 9½-In. Test Bearings

Bearing designation	A	B	C	D
Material	Babbitt	Babbitt	Aluminum	Babbitt
Chock bore, in.	7.8745	7.8745	7.8745	7.8745
Bushing OD, in.	7.8720	7.8725	7.8668	7.8725
OD clearance, in.	0.0025	0.0020	0.0077	0.0020
Bushing ID, in.	7.1320	7.1387	7.1369	7.1387
Sleeve OD, in.	7.1243	7.1243	7.1243	7.1194
ID clearance, in.	0.0077	0.0144	0.0126	0.0193

TABLE II
Specifications of Test Oils

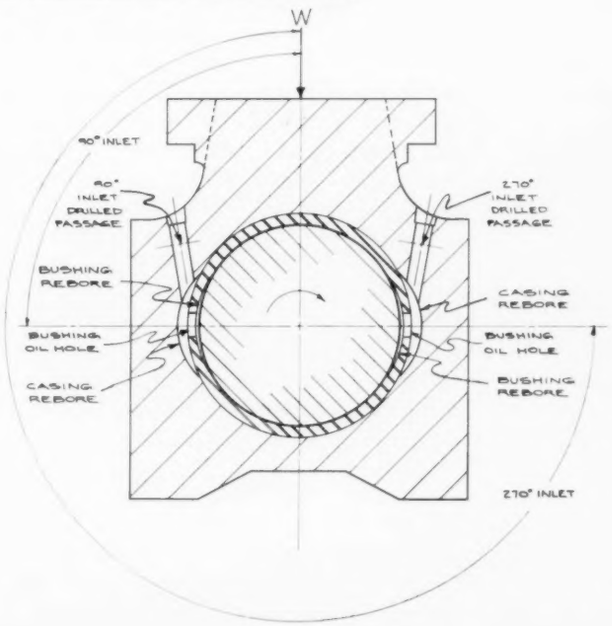
Viscosity, SSU at 100 F	212	2630
Viscosity index	93	95
Viscosity		
Centistokes at 100 F	45.62	567.10
Centistokes at 210 F	6.29	32.40
Specific gravity		
at 100 F	0.858	0.879
at 210 F	0.818	0.840
Demulsibility, federal method 320-32	1620 at 130 F	1530 at 180 F
Neutralization value	0.05	0.03

Each bearing was tested at 27,000, 54,000, 81,000, 108,000 and 140,000-lb loads corresponding to approximately 750, 1500, 2250, 3000 and 4000-psi bearing pressures with each of the oils listed in Table II.

The maximum speed for each combination of load and viscosity was limited by the available torque of the drive motor at weak field. In any case, however, the maximum speed for each load was not less than 1000 rpm. Prior to each run the machine was operated at 300 to 400 rpm under light load for approximately one hr. After warm-up, the test load was applied and the machine run at the starting speed until equilibrium conditions, as determined by oil drain temperature, were reached. The required data was then recorded. This procedure was followed for each speed change. The speed was increased in approximately 200-rpm increments until the maximum speed was reached that could be attained without exceeding the current rating of the motor. The speed was then decreased in increments until reaching the speed at which the motor stalled.

The oil flow was metered by a nozzle in the supply

Figure 10—Two drilled passages were used during the tests for admission of oil to the bearing.



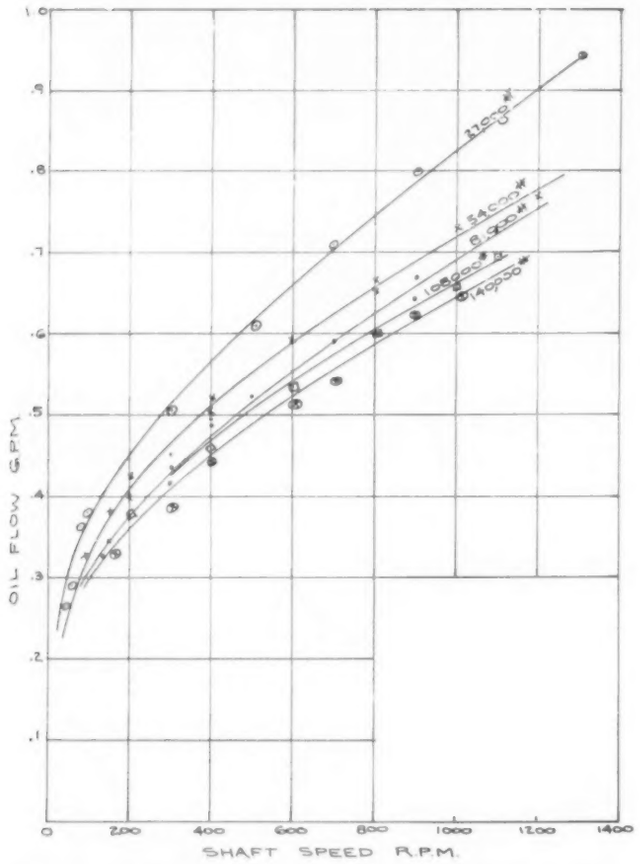


Figure 11—The oil flow decreased as the speed decreased and also as the load increased.

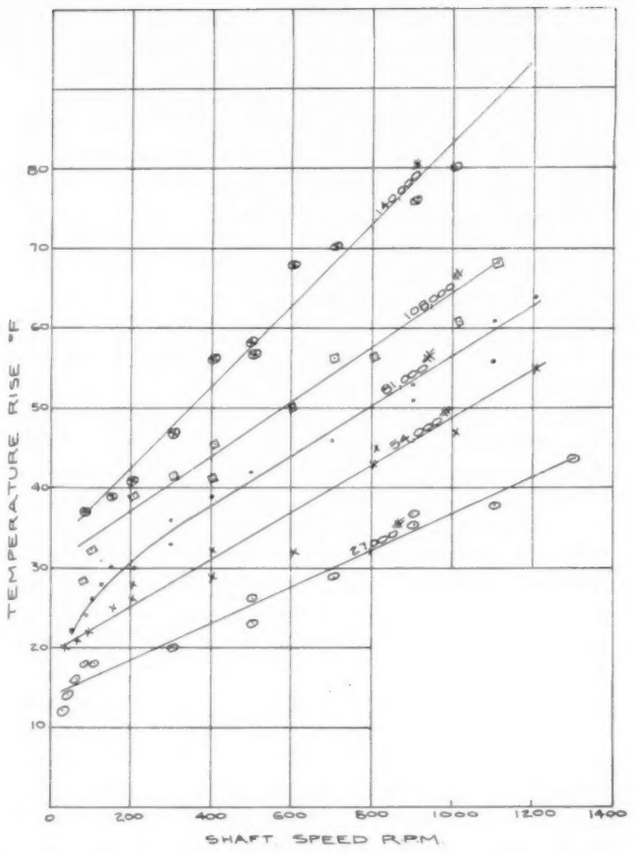
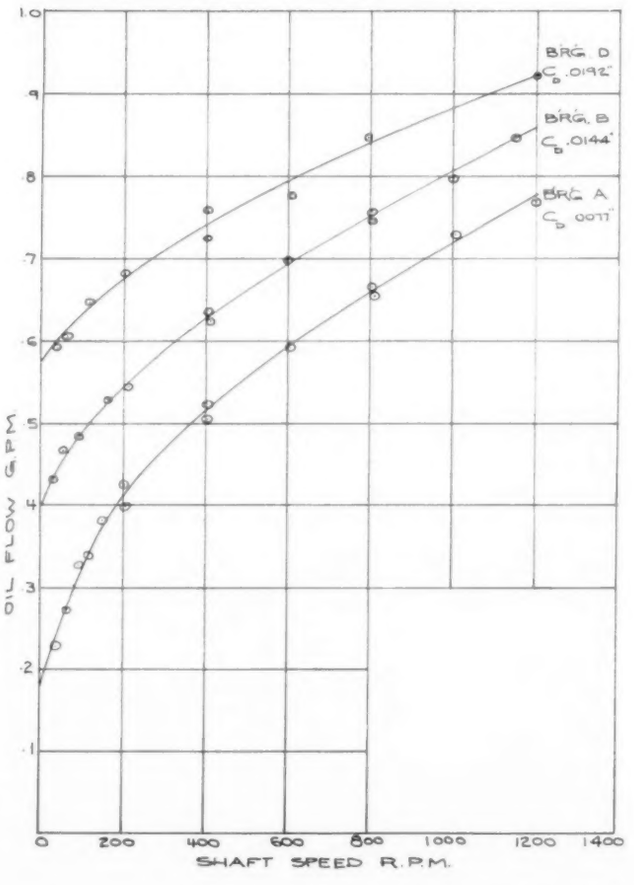


Figure 12—Oil drain temperature rises as both speed and load increases.

Figure 13—Increase in oil flow due to increased clearance is approximately 18 per cent at full speed.



line. However, for this test a calibrated metering valve replaced the standard type fixed nozzle in order to easily change the calibration if desired. The valve was set to deliver one gpm of oil at 100 F with a 15-psi pressure drop, which is the volume that would normally be supplied for a maximum operating speed of 1200 rpm. The oil was admitted to the bearing from the rebore located 90 degrees before the load as shown in Figure 10. For ease in identification this inlet will be referred to as the 90-degree inlet. For the purposes of orientation, this is equivalent to the left hand oil inlet of a top bearing with the shaft rotating clockwise when viewed from the outboard end. This is the standard arrangement for an installation with a single oil inlet.

Figures 11 and 12 represent typical data on the oil flow and oil temperature rise data obtained from this series of tests. This particular data is for babbitt bearing A using the 200-SSU oil. Oil flow increased as expected with increasing speed but decreased with increasing load. Oil drain temperature increased with increasing load and speed. The oil flow for babbitt bearing B was greater than for babbitt bearing A, which reflects the effect of greater clearance. However, the change in oil flow between minimum and maximum loads for both bearings is approximately equal, in spite of the difference in clearance. The drain temperatures for both bearings were of the same order of magnitude. The oil flow at 27,000 lb for babbitt bearing B and aluminum bearing C with clearance of 0.0144 and 0.0126 in. respectively was nearly equal, but at 140,000-lb load bearing C had approximately 15

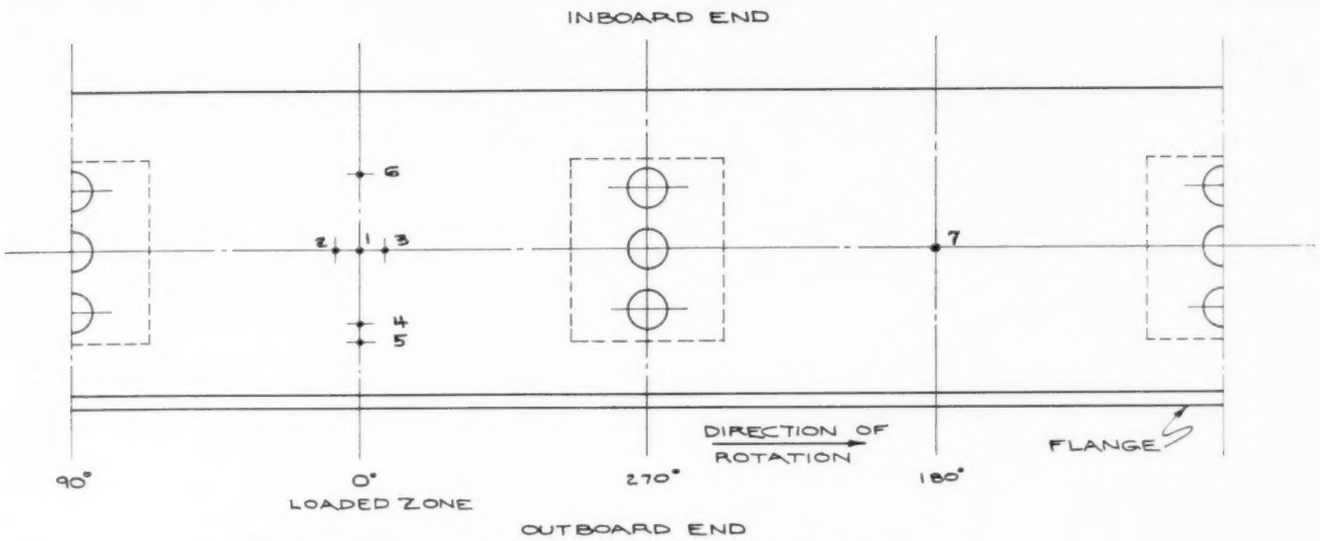


Figure 14—Two bearings were fitted with thermocouples placed as illustrated.

per cent greater flow. Since the coefficient of expansion of aluminum is approximately twice that of steel, the operating clearance of the aluminum bearing is undoubtedly greater than the babbitt bearing at comparable load and speed which would account for the greater oil flow. Oil drain temperatures observed for bearing C were approximately 15 to 20 F lower than for the other two bearings.

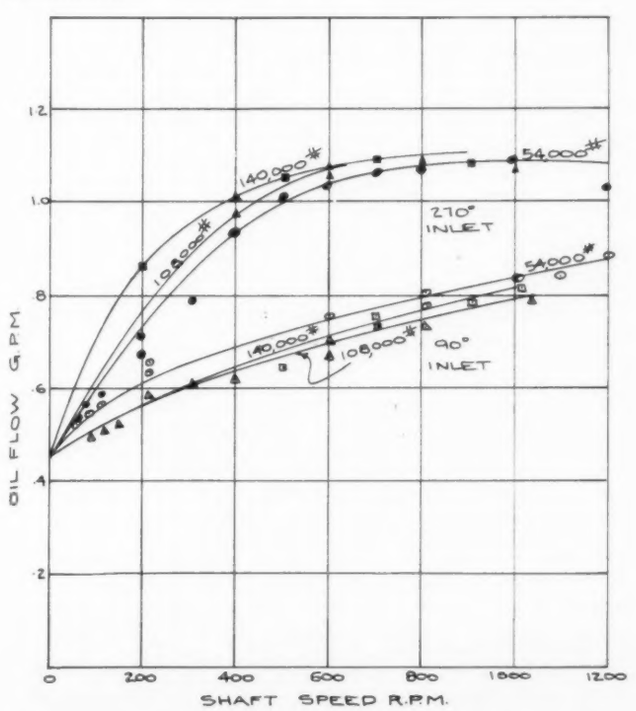
The oil flow and oil temperature rise for those tests using 2600-SSU oil have the same general characteristics, but the oil flow is approximately 50 per cent lower and the temperature rise is nearly double for corresponding loads and speeds. Bearing B failed while running at 900 rpm under a load of 140,000 lb. This operating condition is several times more severe than would be experienced under mill operating conditions. At the time of failure an oil drain temperature of 305 F was observed. In view of the high drain temperature, it is probably safe to assume that the bushing temperature was considerably higher, possibly exceeding the melting point of the babbitt and that this caused the failure.

It should be pointed out that the 9½-in. bearing is most frequently used in the finishing train of a rod mill. In this application the bearings may operate at speeds up to 2700 rpm and at loads rarely exceeding 50 per cent of the rated capacity. Under these operating conditions, it would not be practical to use an oil having a viscosity of 2600 SSU because of the excessive heat that would be generated. The normal recommended viscosity range would be 250 to 400 SSU. Since individual oil-film bearings are relatively insensitive to 300 to 400 SSU changes in viscosity, a 2600-SSU oil was selected in order to determine the effect of an unusually high viscosity on the bearing operating characteristics.

One of the advantages of this type of bearing is that the sleeve can be reconditioned when necessary, note Figure 13. This shows the effect of clearance on oil flow for three babbitt bushings A, B and D. Operating with a load of 54,000 lb and using a 200-SSU oil, increasing the clearance 2.5 times results in an increase in oil flow of only 18 per cent. In view of the fact that oil flow decreases with load and the nozzles are selected to give the required flow at maximum speed, there is a sufficient capacity in the lubricating system to accommodate the increased oil flow resulting from the permissible increase in clearance due to reconditioning.

The next series of observations were made using bearings C and D, aluminum and babbitt respectively, which were fitted with thermocouples. Each bearing was equipped with seven thermocouples, six in the load zone and one in the unloaded side, as shown in Figure 14. Since this chock was equipped with two independent oil inlets, each supplying a separate rebore, it was decided to observe the effect of oil inlet location upon oil flow, drain temperature and bushing temperature. As shown in Figure 10, these inlets are located 90 and 270 degrees before the load in the direction of rotation. For the purposes of identification they will be

Figure 15—Oil flow also varies with regard to the inlet placement.



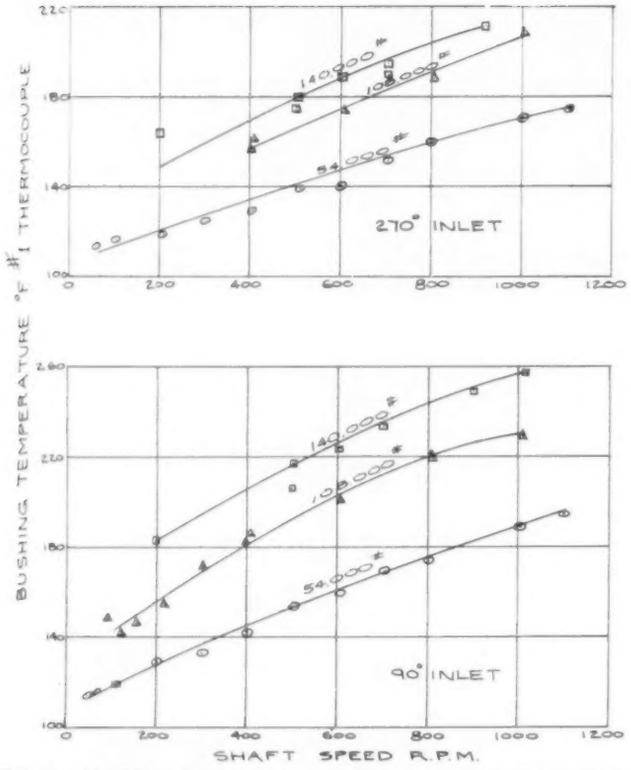


Figure 16—The bearing temperature varied up to 40 F depending upon the oil inlet used.

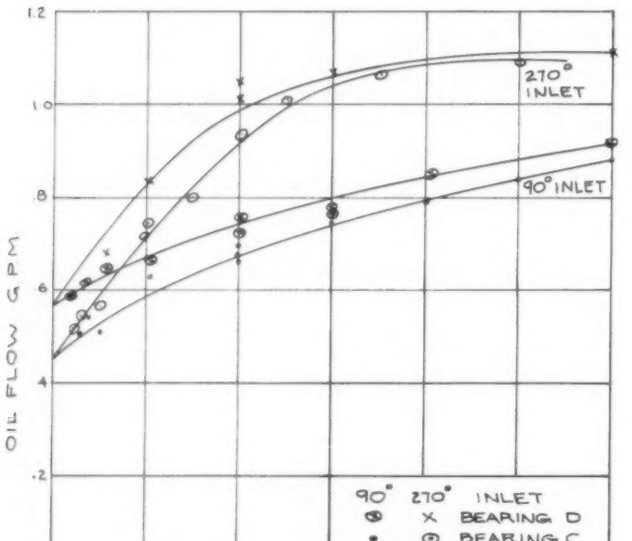


Figure 17—Oil flow characteristics are the same with either a babbitt or an aluminum bearing.

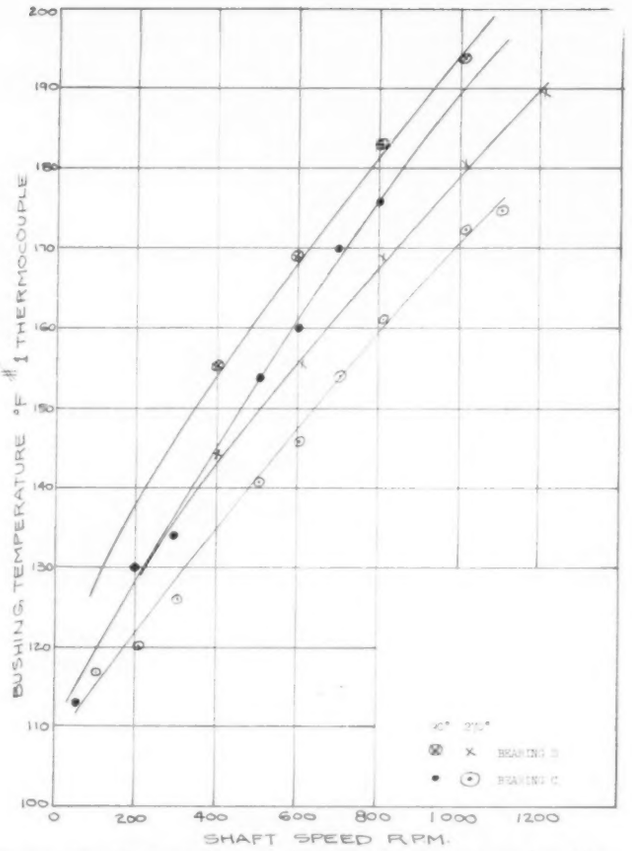


Figure 18—Under the same loading the aluminum bushing operates cooler than the babbitt bushing.

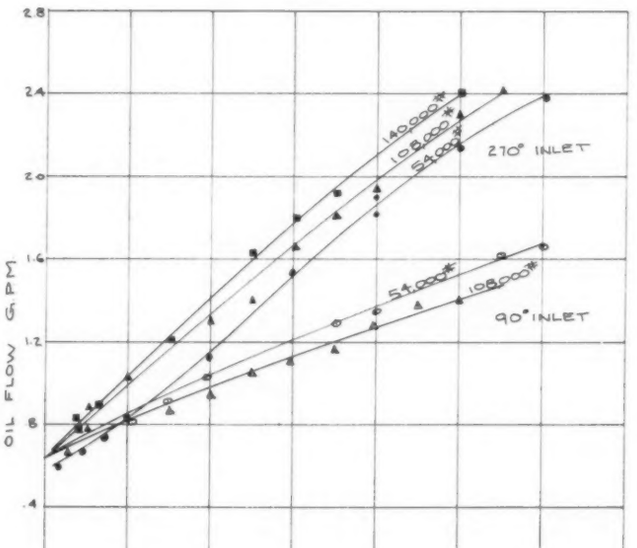


Figure 19—The use of a constant rebore pressure greatly affected oil flows for two inlet locations.

referred to as the 90 and 270-degree inlets. As in the tests previously described, the metering valve was calibrated to deliver one gpm of 200-SSU oil at 100 F and 15-psi pressure drop.

The oil flow obtained for each oil inlet with aluminum bearing C are shown in Figure 15. The lower set of curves refer to the 90-degree inlet and the upper ones to the 270-degree inlet. The 90-degree inlet, as previously noted, shows a decreasing oil flow with increasing load, while the 270-degree inlet indicates that oil flow increases with increasing load. For the 270-degree inlet, regardless of load, the oil flow increases to a maximum of approximately 1.1 gpm. In this case the flow is undoubtedly limited by the nozzle.

Figure 16 shows the influence of speed and load on bushing temperature for the two inlets. This data is for thermocouple No. 1 which was located in the center of the load zone. The other thermocouples showed the same characteristics, varying only slightly in magnitude.

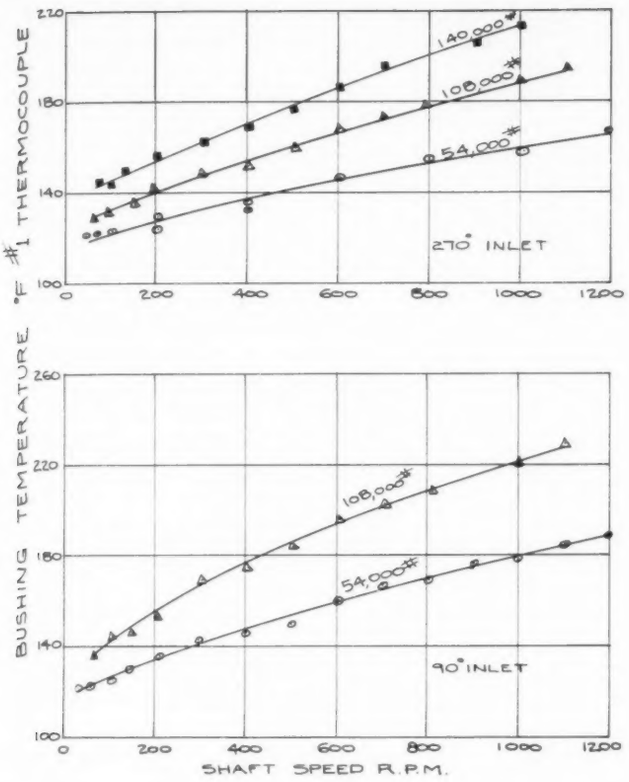


Figure 20—Temperature variations, resulting from difference in oil flow due to inlet location, are quite noticeable.

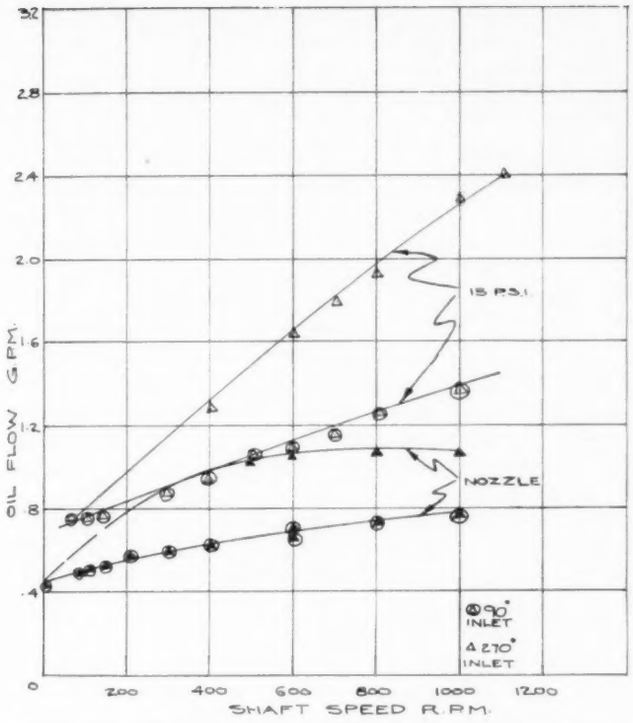


Figure 21—Oil flow is compared with and without a nozzle at a 108,000-lb bearing load.

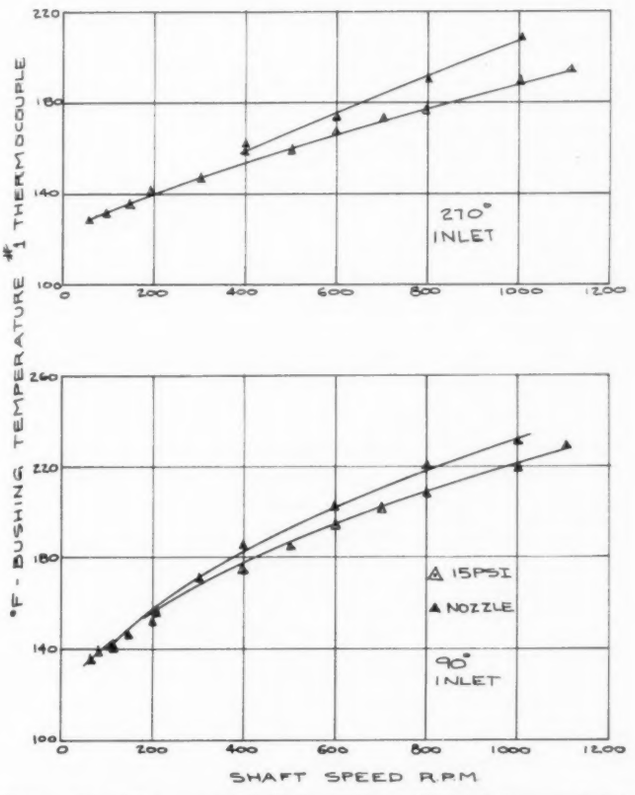


Figure 22—The greater oil flow from the 270-degree inlet reduced the bearing temperature 10 to 20 F.

As expected, bushing temperature increases with increasing speed and load. However, the bushing temperature is as much as 40 F lower using the 270-degree inlet in comparison to the 90-degree inlet. This decrease in temperature can be attributed to the greater oil flow and improved distribution.

Figure 17 shows a comparison between the oil flows for aluminum bearing C and babbitt bearing D at a load of 54,000 lb using both oil inlets. The oil flows for both bearings exhibit the same characteristics. Bearing D because of its greater clearance has a larger flow. However, the flow from the 90-degree inlet for bearing C increases at a greater rate than for bearing D. This is probably due to increasing clearance as the aluminum bushing increases in temperature.

Figure 18 compares the bushing temperatures of bearings C and D under the same conditions. As previously noted the bushing temperatures using the 270-degree inlet are lower than with the 90-degree inlet. The aluminum bushing operates at a lower temperature than the babbitt bushing. Since the oil flow for the aluminum bushing was less than for the babbitt bushing, the lower temperature is attributed to the better thermal characteristics of aluminum.

In order to confirm the observations that oil flow increases with load when the oil is entered in the bearing 270 degrees from the load, and to observe the influence of increased oil flow on bushing temperature, a similar series of tests was made except that a constant pressure of 15 psi was maintained in the chock rebore over the full range of load and speed and without a nozzle. Figure 19 shows the influence of a constant rebore pressure on oil flow for each inlet. As previously shown, the oil flow decreases with load when using the 90-degree inlet. When using the 270-degree inlet the oil flow increases materially with load. As before, the bushing temperature increases with load and speed as shown on Figure 20. There are also significant differences in bushing temperatures between the 90 and 270-degree inlets.

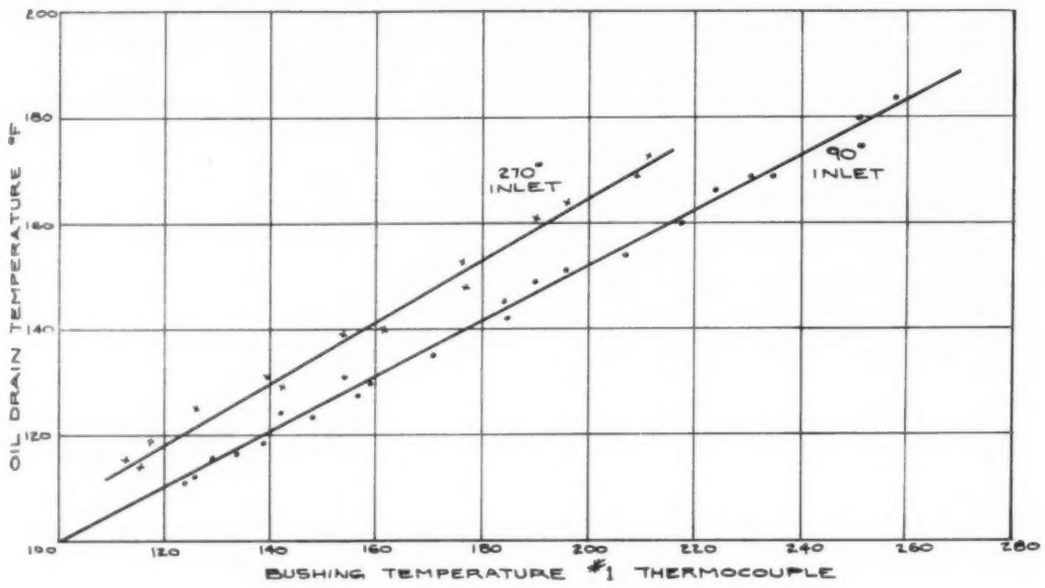


Figure 23—There is about a 20-degree difference between bearing temperatures, at equal oil drain temperatures, with respect to the inlet used.

Figure 21 compares the oil flows observed between a 15-psi rebore pressure and the standard calibrated nozzle. Using the 270-degree inlet the flow is two times greater with the 15-psi rebore pressure, and only 1.75 times greater using the 90-degree inlet. It is interesting to note on Figure 22 that in spite of greater oil flow only a 10 to 20-F drop in bushing temperature occurred. While this appears to be an advantage, it should be pointed out that it would be uneconomical to provide a lubrication system with twice the normal system capacity for a relatively small decrease in bushing temperature.

The relationship between oil drain temperature and bushing temperature at the center of the load zone of bearing C is shown on Figure 23 for both oil inlet positions. This data is from the tests using a standard nozzle. For the 270-degree inlet the bushing temperature is approximately 20 degrees lower than for the 90-degree inlet for equal drain temperatures. It appears that this relationship between drain and bushing temperatures is independent of load and speed, which could make it extremely useful. However, it must be pointed out that these relationships are based upon a limited number of tests, and that they are numerically valid only for this installation. The slope of these curves will undoubtedly be different for bearings operating in the field because of the effect of the roll housing, and for example, the presence of roll cooling water, on the radiation capacity of the chocks.

In view of the limited time available to analyze the vast amount of data accumulated, only a small part which was thought would be of immediate interest has been presented. The investigation carried out thus far represents only a small portion of the total program. For the present the program has been concerned with determining the characteristics of standard bearings as a basis for comparing and evaluating other bearing designs and materials. Currently, equipment is being designed which will permit the measurement of oil-film thickness under varying operating conditions. This is extremely important considering the high operating speeds encountered in modern mills.

This progress report indicates the active research program being pursued in this field. Industry requirements for roll neck bearing operations continue to become more exacting. It is only through continued research that the bearing requirements of tomorrow will be met.

Discussion

PRESENTED BY

C. A. BAILEY, Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

ANDREW E. CICHELLI, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

NORMAN A. WILSON, Manager of Research, Morgan Construction Co., Worcester, Mass.

C. A. Bailey: Were both a 200 and 2600-SSU oil, with their respective ZN/P calculations, used in the test, or was this one bearing designed with the viscosity ranging from 200 to 2600 SSU?

Would it be possible to project the ZN/P calculations below 200 SSU or to the viscosity of water? If so, could sufficient properties be indicated to enable the steel industry to lubricate its backup rolls with the solution?

Has any work been done, or is any contemplated on the wiping of bearings when starting, from static loading?

Andrew E. Cichelli: Bethlehem Steel Co. conducted a similar test on a mill stand, whose roll neck diameter was 33 in. The author's test bearing had a diameter of 7½ in., so perhaps the results should not be compared. However, there were many similarities between the results, for example, in the temperature rise in the bearing. Thermocouples were used in the bearing, several of them located in the load zone. The oil entry temperature was 100 F and the oil drain tem-

perature was about 140 F. The thermocouple temperatures were 270 F for the bearing itself.

Now these temperatures can be correlated, because the oil-film temperature reading only represented a small fraction of the total oil going through the bearing.

The oil drain temperature, 140 F in our case, was actually the average temperature of the oil passing through the load zone plus the oil enveloping the bearing outside the zone. The extra amount of oil over and above that supporting the load, flowing through a bearing is for cooling purposes.

The bearing supporting the load will only permit a specific amount of oil flow under specific conditions of speed, load and oil viscosity. Therefore, it is not possible to force more oil through, than the bearing can accept in this zone. However, the balance of the area around the bearing will accept as much oil as the system capacity will allow and thereby reduce oil drain temperature without reducing the oil supporting film temperature.

The authors have indicated that they can force more oil through a bearing, for example, by three times and reduce its temperature. How much flows through the load zone is a theoretical question and cannot be measured, but it can be estimated mathematically.

When one speaks of 2000 psi in the bearing, one is speaking of an average pressure. No such condition prevails throughout an actual bearing. There are only two points on the load distribution curve that reach 2000 psi. The curve, representing the load distribution of the bearing, resembles a parabola. The peak of the parabola is two or three times the average height. So, 2000 psi means there are 6000 psi at the peak. Therefore, the bearing material and the oil must be able to withstand three times average psi. The authors are aware of this, but it is an important consideration in the selection of the oil for the bearing as well as in its structural design.

Norman A. Wilson: This bearing was not designed for viscosities ranging from 200 to 2600 SSU. The majority of the test work was carried out using 200-SSU oil. The 2600-SSU oil was used merely to determine the effect of a heavy viscosity upon the characteristics of the 9½-in. test bearing. A 2600-SSU viscosity would normally be an unrealistic specification for this particular size bearing, since it is generally used in rod finishing mills. In this application the bearings speeds are approaching 2700 rpm with loads up to 1500 psi.

There are no plans at the present to investigate lubricant having viscosities approaching water or even using water with lubricity additives. The use of roll lubricants as possible substitutes for straight mineral oils on cold mill applications has been considered.

As part of the complete bearing program, it is intended to study the starting characteristics of the existing bearing materials and also other materials. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering and so forth should be directed to that address.

1464 WARTMANN, R.: "Fundamental principles on the digital presentation and processing of data with special references to computers," *Arch. Eisenhut.*, 1959, Aug., pp. 513–518. Numbers can be represented by corresponding analogous physical values (distances, voltages, etc.). There exist appropriate machines operating on the analogue principle in which mathematical formulae are expressed by physical laws and others operating purely arithmetically. Electronic computers belong to the arithmetically operating type of machines. Normally the former are not based on the decimal but on the binary system or related notations which have the characteristic of requiring only the figures 0 and 1. Numerical representation in computers is thus possible with elements which can assume only 2 different conditions, e.g., positive or negative magnetization, conducting or not conducting current and the like. In addition calculating switches used for these special numerical systems offer many advantages. Storage units, in which numbers (e.g., partial results) can be stored, form further elements. The most important storage units are briefly described. (Author's summary.)

1598 PECORARI, A.: "The Lubatti electric process for reduction of ores," *Radex. Rund.*, 1954, (4/5), pp. 152–164. (From German.) (A description is given of the operation of the Lubatti furnace, used for smelting powdery low-grade ores with coal dust, the steel being obtained direct from the ore without intermediate pig-iron stage.) (Abstract *J.I.S.I.*, 1955, Oct., p. 174)

1691 GUNDEL, M. "Investigations on the economic operation of d-c reversing rolling mill motors for heavy rolling mills," *Metallurgi eu. Giesserei Technik*, 1955, Feb., pp. 50–60. The results of calculations and tests to determine the actual loads on d-c motors for reversing mills are presented. The author concludes that changes of speed during rolling are desirable and advocates automatic control. (Abstract *J.I.S.I.*, 1955, Oct., p. 181)

1699 ZWICKY, R. "Automation in continuous rolling mill trains," ETZ-A, 1957, Dec. 1, pp. 869–873. (The original, almost universally used, open stand rolling mills for wire rod, light sections and strip rolling, have in recent years given way more and more to self-regulating continuous mills. After introductory discussion of this development, the conditions for continuity, characteristics of control and loop regulation used in recent drives are described. Since ancillary drives and devices are the basic elements in automation for rolling mills, they are considered in detail. Among ancillary equipment, action of photo-relays and electronic time-lag relays in particular is described. Finally travel of the work through highly automated continuous mills is reviewed broadly.) (Author's summary.)

Applying Clear, Mill Type Pipe Coatings—Methods and Problems

by DONALD A. GOLBEY
Sales Engineer
The Cleanola Co.
Glenshaw, Pa.

. . . . prevention of pipe corrosion requires a uniform, quick-drying coating of protective material, with equipment for easy and economical application . . . .

RUST and corrosion are deadly enemies of the metal industries and the industries have long realized the importance of protective coatings. Indeed, their search for more durable finishes has been a prime mover of coating manufacturers and coating equipment builders.

The pipe manufacturers, being one of the larger users of metal, have for almost 60 years found it imperative to apply protective coatings from both a quality and economic standpoint. It was shortly after the turn of the century that the tube and pipe mills began the practice of coating of pipe with petroleum base oils to prevent corrosion. They realized that because of corrosion, tremendous quantities of pipe became unsalable between the time of manufacture and the time of use. The types of oils used with this early application were far from being good rust preventives. This, combined with the fact that most of the oil drained off the pipe shortly after application, sent the industry searching for something better.

About 1913, the first clear, oxidizing or drying-type coating was used. This material was a varnish composed of rosin, linseed oil and a solvent. A few years later, research was begun by the manufacturers of coating materials to find better materials and answer the problems encountered with the older ones. This quest for knowledge finally led to the discovery of many of the synthetic resins which are used commercially today.

From this research the equipment necessary for applying varnish coatings to pipe evolved. The original varnish coatings were applied to pipe by hand brushing. This method created no problems from a quality point of view, provided the individual making the application was reasonably careful. From the production angle, however, the coating of pipe became a bottleneck and faster means had to be found. The flood and wipe method, which was in common use for applying the petroleum base oils, became the common method for applying varnish coating materials. Many problems were encountered with this method, some of which existed until recent times because they were not understood. The most vexing of these problems are caused by the collection and reuse of excess varnish. Oil, water and mill scale become mixed with this reused material and actually cause chemical changes in it. It can readily be seen that as this cycle continues, the corrosion resistant properties of the original material can be changed drastically. Many times the producer of the coating varnish has been asked by the user to explain why his material is not giving the same results as it did at first. The answer, of course, is that they are not using the same varnish as originally supplied. In many cases the problems became worse with the introduction of newer synthetic resin varnishes. The stability of these

newer materials is less than that of the rosin linseed oil varnishes.

About the same time that the scientific approach to protective coating problems was beginning, the air spray gun was developed. The air spray gun was quickly utilized by mills and equipment builders who felt that this method of applying varnish coatings to pipe showed a considerable improvement in coating quality over that applied by the flood and wipe method. No attempt was made to collect the oversprayed coating material and recirculate it. Economically however, this method proved inferior to the flood and wipe method because 50 per cent or more of the coating material sprayed was lost. In addition, most of the mill areas, where air spray coating of pipe was being done, were very unpleasant places to work. A ten to one air to liquid ratio was normally used to affect atomization, and this great quantity of air poured forth from the spray booth carrying solvent vapors and coating material. The airborn varnish, besides being unpleasant and unhealthy, also created problems of housekeeping as it settled on everything in the area. Where exhaust stacks were used, the vapors in the mill were reduced, but fires in the stacks were not uncommon.

Maintaining continuous and uniform coatings was another problem found in equipment of this era. As the viscosity increased, due to loss of solvent or lowering temperatures, the amount of coating on the pipe increased. These heavy coatings dry more slowly, curtain and also cause sticking of the pipe in the bundles. Solvent washing may occur when the solvent vapors, released from the heavy coatings of bundled pipe, condense on the surface of other pipe in the bundle. As a result, the coating in these areas flows and leaves many bare spots on the pipe.

Reduced viscosity caused by too much solvent results in thin coatings which do not afford sufficient corrosion protection.

Either extreme is undesirable and for this reason it is of the utmost importance that a solution to this problem be found. As the builders of coating equipment increased their understanding of these problems, many novel and partially successful systems were devised. However, it was not until 1956 that the problems caused by recirculation of oversprayed material and other common problems were overcome.

Work had been started many years before by engineers who were familiar with coating problems. They reasoned that if spray heads could be designed which were capable of applying 90 to 95 per cent of the sprayed coating to the pipe, the need for direct recirculation would be eliminated and the problems of loss of solvent, premature oxidation, clogging of the fluid system with dirt, and the contamination of the coating material with oils, water and shop dirt would be cured.

A spray head unit was designed with synchronously adjustable nozzles. These nozzles produce a fan-shaped spray pattern, the angle of which is changed with changes in pipe size. For example, when small OD pipe is to be coated, the fan-shaped pattern is turned to produce a very narrow stripe on the surface of the pipe. As the pipe size increases, the angle of the pattern is increased to produce a wider stripe on the surface. Six spray guns are used in the spray head unit to produce a series of interlocking stripes on pipe sizes from $\frac{1}{2}$ to $6\frac{5}{8}$-in. OD. Twelve spray guns are normally used to get uniform coverage on pipes larger than $6\frac{5}{8}$-in. OD. All the nozzle angles are mechanically linked. Merely by turning a crank on the outside of the cabinet to a predetermined angle setting, a consistent uniformity of coating is assured.

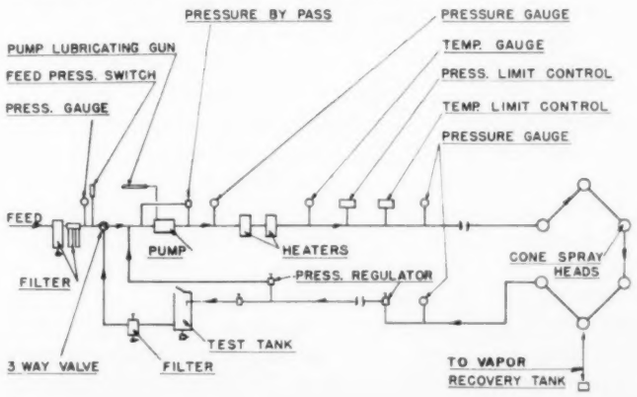
A means of turning the spray guns on and off as pipe passes through the field of the nozzles had to be developed. To accomplish this, the spray guns were designed with solenoids that are an integral part of the gun. This eliminates the possibility of leaks under high pressure because there is no packing gland. The solenoids are actuated by timers connected to a flag or proximity switch located on the entrance conveyor. As the front end of a piece of pipe depresses the flag switch, a timer is set in motion. This timer is adjusted according to conveyor speed to operate the spray guns as the pipe reaches the field of the nozzles. Another timer is activated when the flag switch is released after the end of the pipe passes over it. This too is adjusted according to conveyor speed to turn the spray guns off when the pipe is out of the field of the nozzles. By this method of using two sets of timers, random lengths of pipe can be coated without making any further adjustments of the spray cycle. Another advantage of this control setup is that the sprays will shut off between lengths of pipe even though they follow one another very closely.

Operational data obtained from a pilot model coater showed that by using adjustable spray nozzles and precise timing of the cycle, 95 per cent and better efficiency was normally achieved and the need for direct recycling of oversprayed material was eliminated.

Many of the other problems not directly connected with recirculation of oversprayed material were minimized by the incorporation of the hydraulic pressure system of spraying and by the use of explosion-proof electric heaters to maintain viscosity control of the coating material.

The hydraulic pressure system of spraying depends on fluid pressures of 200 to 600 psi (rather than air) to atomize the spray. Use of this method of spraying eliminates the need to flush out the fluid system with solvent after use because there is no air in the system to oxidize the coating material and cause clogging with varnish skins. In other words, varnish in the fluid system will remain in the same condition as it would in a sealed drum. Vapors from spraying are also much more

Figure 1 — Constant circulation of the varnish assures proper temperature at the spray heads.



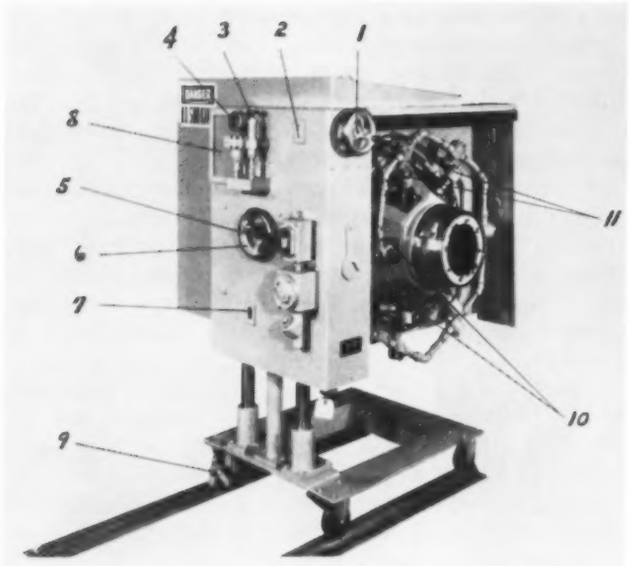


Figure 2 — The unit illustrated shows the positioning of the adjustable spray heads.

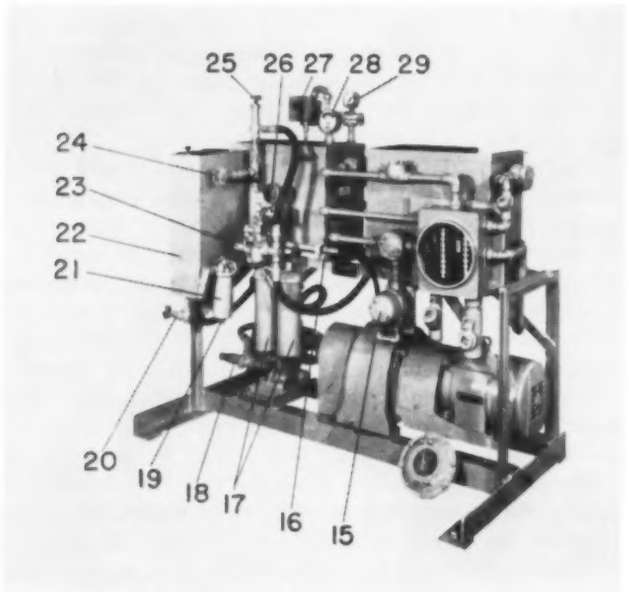


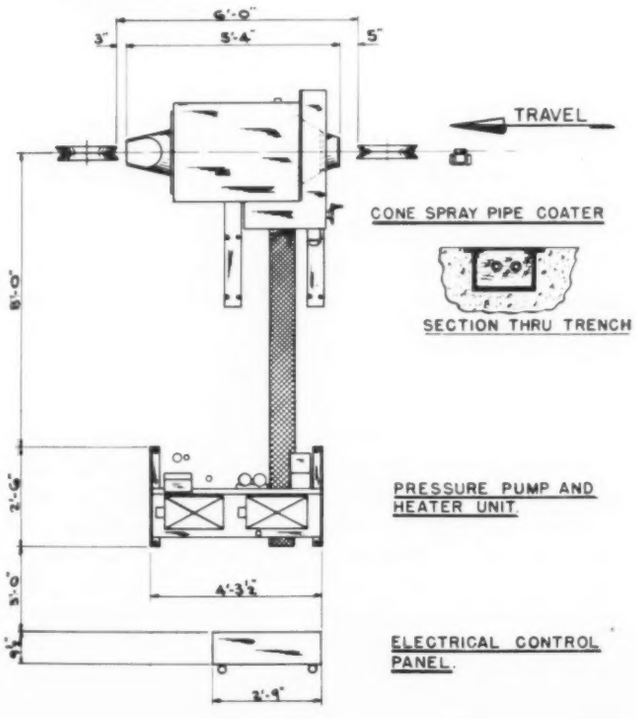
Figure 3 — The pump and heater units are compactly grouped on a single frame.

easily confined by the cabinet without benefit of an exhaust when this system of spraying is employed because no air is introduced into the cabinet. It should be noted that vapors outside the cabinet are further minimized by turning the spray guns off when no work is being coated and by using higher solid content varnishes. The use of higher solid content varnishes will be discussed later.

The liquid circulation of material for the hydraulic pressure method of spraying is shown in Figure 1. Varnish is supplied under 50 psi to the intake side of a positive displacement pump. This pump is of special design and uses teflon packing and a special lubricant to withstand the effects of varnishes and solvents. A cartridge filter and a self-cleaning filter are normally installed ahead of the pump to remove any filterable material. From the pump the flow is through one or more heaters. The number is determined by the lowest temperature reached by the stored varnish. The coating material is then pumped through a temperature limit control and a low pressure switch which turn off the heaters if the temperature rises above the internal thermostat setting or if the pressure drops for any reason. The flow continues to the spray guns, through a quick-acting pressure regulator which maintains an even back pressure on the spray guns. The varnish then returns to the intake side of the pump. You can understand that with this flow arrangement there will always be varnish of a constant temperature in the spray heads when the machine is running, regardless of whether varnish is being sprayed or not. The amount of material circulating through the heads is many times greater than the nozzles are capable of spraying. In operation the entire fluid system holds about three gal of material.

There are many reasons for including heaters in this piece of equipment. The prime one is to control viscosity and thereby control accurately the amount of flow through the nozzles at any given pressure. In addition to viscosity control, heating the varnish reduces the viscosity and allows higher solid content materials to be used. These higher solid content varnishes are less expensive to use because less solvent is used. They do not run or sag as easily; also, they produce heavier dry films in proportion to the wet film thickness since less solvent must come off before the coating sets. Again, because there is less solvent, there are less solvent vapors. Figure 2 shows the cabinet unit and the convenient arrangement of the controls necessary for adjusting the equipment when pipe sizes are to be changed: No. 1 identifies the crank handle for adjusting the nozzle angle. All the nozzles are mechanically linked to this point and are adjusted simultaneously. No. 2 is the dial that indicates the nozzle angle. No. 3 and 4 are the pressure regulator and pressure gage. No. 5 is a test button for operating the sprays. This allows the

Figure 4 — Normal installation and distances between units are shown.



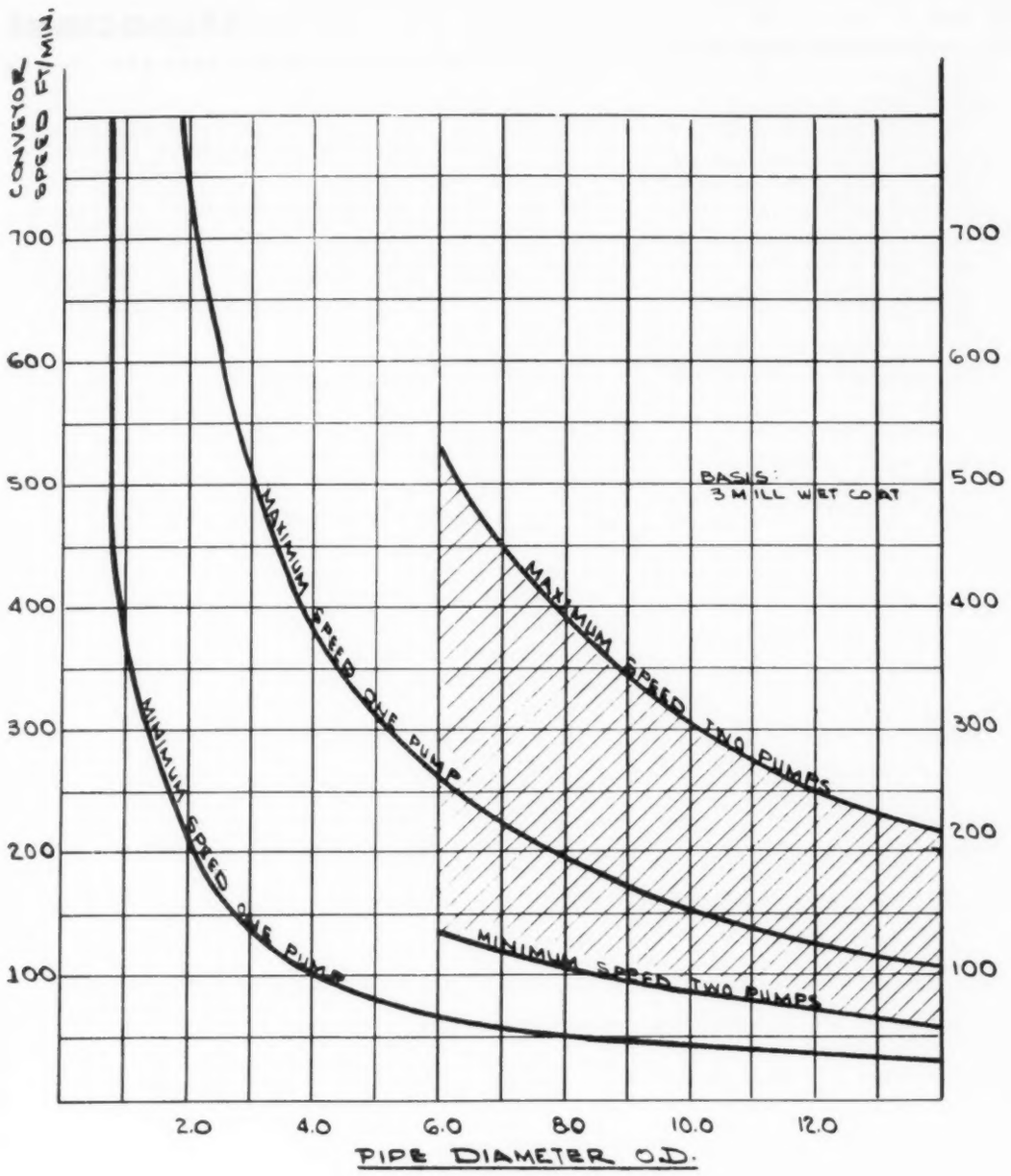


Figure 5 — Speed of coating is plotted as a function of pipe diameter and number of pumps used, assuming a desired coating thickness of 0.003 in.

operator to check the condition of the nozzles without needing the assistance of someone else to depress the flag switch on the conveyor. No. 6 and 7 are the crank for making elevation adjustments and the dial that shows what the adjustment is. No. 8 is a frame that holds the operator's adjustment chart. He reads from this chart the nozzle angle setting, the pressure and the elevation of the cabinet for any given pipe size. No. 9 is a lock to hold the cabinet in position in the line. The base of the cabinet is on wheels mounted on a track. This is so the whole cabinet can be moved out of the line when maintenance is needed. The safety of this feature is readily discernible.

Nos. 10 and 11 point up the adjustable spray heads, solenoids and explosion-proof fittings. This area of the cone spray machine is not normally visible since a cover encloses it to protect it from dirt. It is not necessary to remove this cover when nozzles are to be changed.

Figure 3 shows the pressure-heater unit and how the motor, gear reducer, pump, heaters and filters are all mounted on a single frame which requires relatively little floor space. No. 22 points to a feature that has been found to be very useful. It is a test tank from which samples of new or different coating materials can be drawn, simply by throwing a 3-way valve. This eliminates the need for disturbing the main storage supply and thereby minimizes the chances of drawing air into the fluid system. When the tests with the new material are completed, the 3-way valve is then returned to normal operating position and coating material is again drawn from the main supply.

The spray cabinet and pressure-heater unit are normally laid out as shown in Figure 4. The distance between the rolls required for the spray cabinet is usually about six ft. The pressure-heater unit normally requires 4 ft-3½ in. x 2 ft-6 in. of floor space. The electrical control panel can be mounted on the wall or on supports at any convenient distance. In some states this cannot be closer than 25 ft. The interconnecting hoses are run through a trench and are covered with an insulating material. The interconnecting wiring is run

through conduit laid in the floor.

The approximate speed range for pipe of different sizes is shown in the graph in Figure 5. The unshaded area shows minimum and maximum speeds for pipe from ½ to 6⅝-in. OD when six spray guns are used. The shaded area indicates minimum and maximum speeds for coating pipe from 6 to 14-in. OD when twelve spray guns are used. While speeds outside of these limits would mean a drop in efficiency, it is sometimes possible to minimize the drop through the use of different size nozzle orifices or by changing the viscosity of the coating material being used.

This article has tried to explain the more important problems encountered in applying mill type coatings to pipe and to show the solutions used to overcome these problems. It is felt that by eliminating the practice of recirculating oversprayed material, the greatest number of problems are eliminated. By including heat control and the high hydraulic pressure system of spraying, most of the others are overcome. In addition, there has been an attempt to anticipate the problems created by future coatings. The spray heads are made from stainless steel and will be able to handle the water base coatings that are in the development laboratory at the present time.

This equipment has been purchased by many of the nation's largest pipe producers. After thoroughly testing it on varying sizes of pipe, they have returned to purchase additional units to replace obsoleted equipment. Their repeat orders is the highest compliment that can be paid to the unit's engineering soundness.

Discussion

PRESENTED BY

JAMES MAC GREGOR, Sales Engineer, Aetna-Standard Div., Blaw-Knox Co., Pittsburgh, Pa.

DONALD A. GOLBEY, Sales Engineer, The Cleanola Co., Glenshaw, Pa.

A. B. GLOSSBRENNER, Superintendent-Conditioning, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

James MacGregor: The unit shown is for handling a single pipe at a time. Are there machines capable of handling pipe in multiples of three or four at a time to permit an increase in production from that indicated?

Donald A. Golbey: There is manufactured equipment that is capable of coating two lengths of small diameter pipe simultaneously. In most cases, this is sufficient to meet production requirements since these two lengths can be coated at speeds up to 1000 fpm. When three and four lengths of pipe are coated at one time, the efficiency of the equipment drops off due to the difficulty in arranging the nozzles to keep overspray at a minimum.

A. B. Glossbrenner: Have you ever had any plugged valves or nozzles as a result of chemical separation around the heating units?

Donald A. Golbey: There has never been any difficulty of that sort. ▲

Revised and rearranged collection of articles which appeared in the Iron and Steel Engineer between 1943 and 1950 . . . a book for rolling mill men and for anyone interested in rolling mills and roll design . . . written from a practical viewpoint by one who has had considerable experience in the art of roll design.

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1010 Empire Building **Pittsburgh 22, Pa.**

Trends in Rolling Mill Drive Design

Selection of the tooth form, the lubrication method, the bearing type and housing rigidity are items which must be thoroughly analyzed before the correct selection of a gear unit can be made.

by ROGER JONES
Sales Manager, Metal Producing Industries
Industrial Products Div.
Western Gear Corp.
Belmont, Calif.
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Seattle Works
Western Gear Corp.
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THE history of the steel industry is highlighted by major advances in metallurgy and rolling techniques. Emphasis upon these subjects has resulted in development of higher tensile strength steels and production rates that were believed impossible 30 years ago. Not to be omitted from the improvement picture are increased product ranges and accurate quality control.

These improvements are needed by operating and management men to keep pace with competition. Behind all this progress is a story of mill drive development both interesting and important to plant engineers. As equipment and maintenance costs steadily increase, this story should be better known to plant investors.

The story begins in the rolling mills of a modern steel plant. It is repair day and the maintenance crew has just installed a new set of herringbone gears in a mill drive pinion stand. The cover is not in place, and it can be seen that the gear teeth are foundry cast and that the wearing surfaces are very uneven, see Figure 1. The bearings are cast rough babbitt and have at least 1/8-in. shaft clearance. Pinion necks show rough grinding. The pinions were cast from work hardening steel supposedly making them too costly to precision machine. The cover is loosely set in place. A pail of heavy black oil is poured on the train, and a signal to start the drive is given. Vibration makes the floor quiver. A grinding noise comes from the case. Sparks and smoke billow from the inspection openings. The mechanical foreman explains that this is the break-in run. Later it is explained that the process includes a handful of sand to act as a lapping compound. When too much heat is generated, water is added to the mixture.

At the end of the break in (indicated by a drop in noise level), the pinions are removed, cleaned and reassembled for mill operation. The whole process has consumed many man-hours of labor and will have to be repeated again in about three months. The foreman explains that this is a very antiquated drive which will be replaced with a new design. However, the new unit

Figure 1 — As-cast tooth forms have been used for many years.

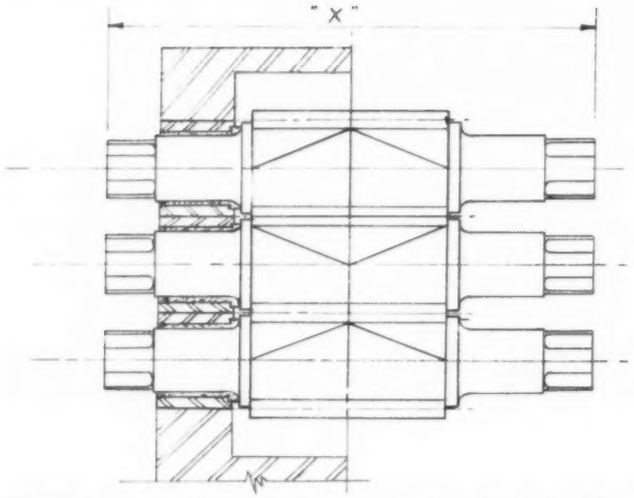


Figure 2 — The gears are protected by shroud rings which prevent tooth bottoming in cases of bearing failure.

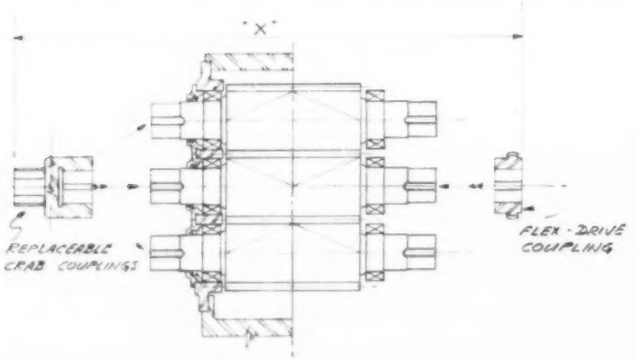


Figure 3 — Anti-friction bearings and replaceable couplings can eliminate many maintenance problems.

will be a copy of the old unit, except that the gear teeth will be cut rather than cast. The same size and shape of gear will be used to avoid purchase of a new housing. The improvement is minor, and with luck, set changes will now occur every six months rather than every three.

Perhaps this story is exaggerated to some degree, but it is true that many cast tooth gear drives are still in active operation. Replacements are necessary much more frequently than would be experienced with modern equipment.

MODERN EQUIPMENT

Many people in the steel industry consider mill drive reducers and pinion stands as a relatively standard commodity in which design changes have not occurred, or have been needed, for years. This is not the case.

Figures 2 and 3 show some basic differences between the old and the new in pinion stand design. Figure 2 shows a typical 3-high set with babbitt bearings and wobbler ends as an integral part of the pinion bodies. The teeth may or may not be cast. Shroud rings are added to prevent tooth bottoming in case of bearing failure. The teeth are usually of heavy pitch in the hope of gaining added strength.

Figure 3 shows the modern arrangement of a 3-high, anti-friction bearing equipped pinion set. Dimension X in many cases of replacement can be maintained or even reduced. This means that replaceable crab or gear couplings can be added to keyed pinion shafts eliminating end wear completely. This has been a major reason for pinion replacement in the past. The double oil seals, a complete self-contained oil circulating system and a sealed case further improve the unit. The use of AGMA speed reducer design standards has given meaning to ratings and service factors. A pinion stand can now be accurately designed for any specific job.

The usage of the words speed reducer and pinion stand might be questioned, and at first one might consider that "gear tooth" and "set of pinion gears" are the subjects being discussed. However, it must be remembered that no gear set can be any better than the housing in which it is carried. The housing must support the gearing and bearings and shield them from mill scale and other harmful contaminants. Also, the bearings must do their part in maintaining gear alinement. The lubricant system must continually function, supplying the lubricating and cooling oil to bearings and gears. The best set of gears that can be built cannot function any better than the cast gears previously described if it is not supported in a manner that will permit the entire face width to share the load at all times, see Figures 4 and 5.

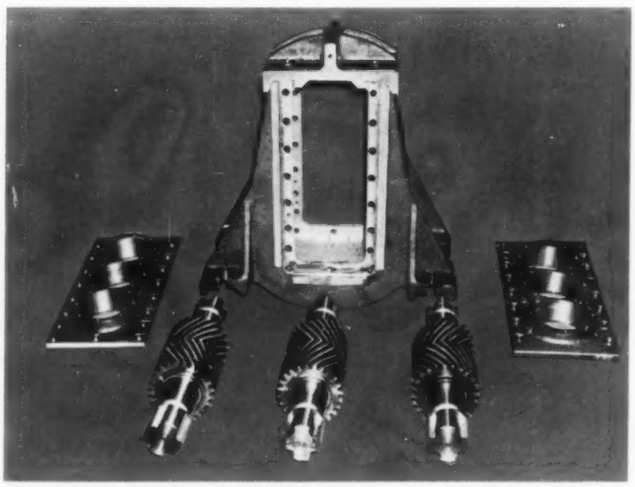
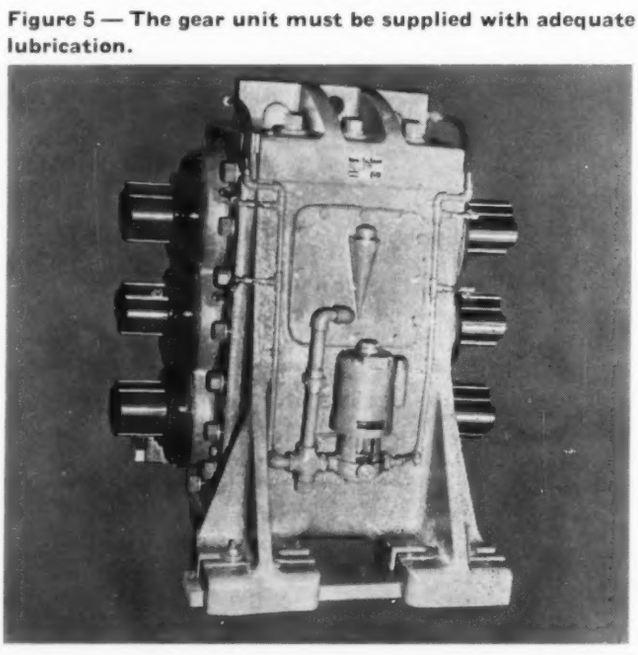


Figure 4 — Accurate machining permits maintenance of required tolerances in assembling pinion units.

Figure 5 — The gear unit must be supplied with adequate lubrication.



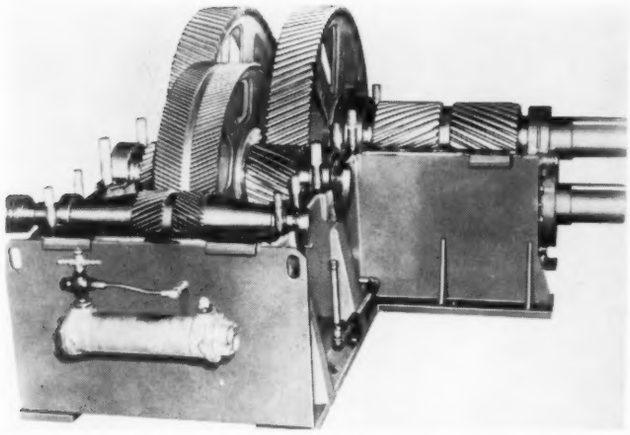


Figure 6 — Speed reducers and pinion stands can be combined within one housing.

COMBINATION UNITS

In a further effort to improve mill drives and at the same time reduce first cost, the trend has now moved a step further than the pinion stand. An excellent arrangement can be worked out by use of a combination of speed reducer and pinion stand as one integral package, see Figure 6.

Years ago this arrangement was viewed by plant engineers as a poor operation risk because a set of pinions could not be changed without dismantling the entire speed reducer. Referring again to the recent changes in pinion design the use of anti-friction bearings and replaceable wobbler couplings has made the possibility of pinion failure extremely remote. Further insurance against this possibility is assured by insertion of a shear pin coupling between the drive motor and the speed reducer section. Essentially by properly engineering the drive for the job to be done there is no longer any need for a separate pinion stand and speed reducer for any new installation.

The gearing shown in Figures 4 and 6 may appear to have smaller teeth than many people are accustomed to seeing in mill equipment. This is because the gears have been selected for their applications in accordance with the surface durability formulae of AGMA. These formulae consider pinion diameter, diameter of the mating gear, face width, material hardnesses, speed, pressure angle and tooth form when calculating for durability. Tooth size or pitch is not mentioned. In fact, unnecessarily coarse pitches may adversely affect durability. The aim is to prevent the surface of the teeth from being stressed to the point of fatigue or deformation.

The surface of an involute gear tooth at any point is a circular arc. The further below the pitch line one goes, the smaller is the radius of the circular arc, until at the point of intersection of the base circle with the gear tooth profile, the radius of the theoretical tooth profile becomes zero.

Consider a set of mill pinion stand gears with a one to one ratio as an example. The most favorable tooth contact conditions are obtained at the pitch line, where the radius of curvature of the mating tooth profiles is determined by the pitch diameter of the gears and the pressure angle selected.

For this example it is assumed that the 20-degree

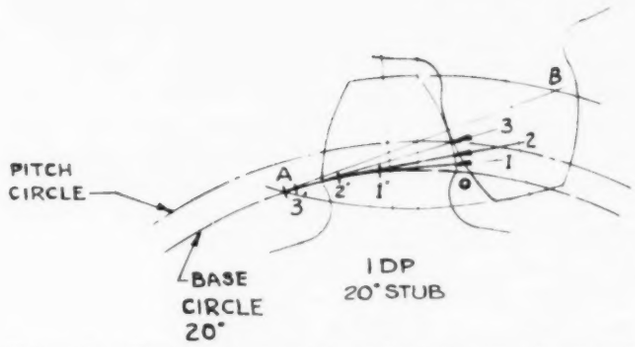


Figure 7 — Teeth of two mating 12-tooth, one diametral pitch pinions are illustrated in which: A–B is the line of contact action; the radius at 2 is 2–2′; the radius at 3 is 3–3′; the lowest point of contact is 0; and the point of contact with the OD of the mating pinion and point of greatest wear is also 0.

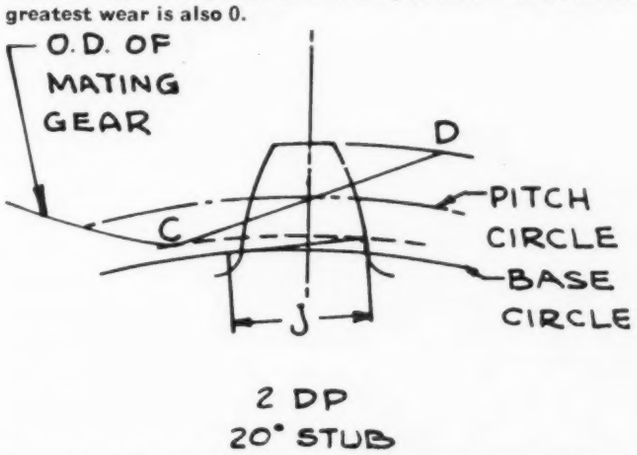


Figure 8 — The tooth of a 24-tooth, two diametral pitch pinion is illustrated in which C–D is the line of contact action; and the radius of curvature at the lowest point of contact is J.

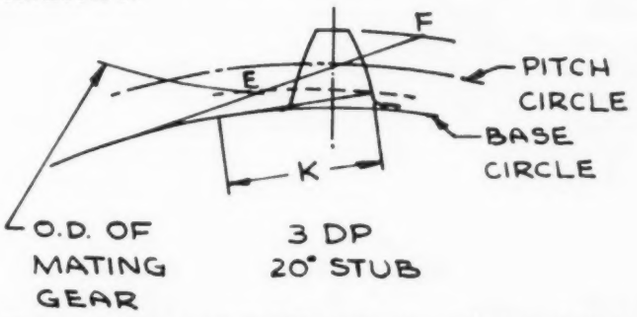
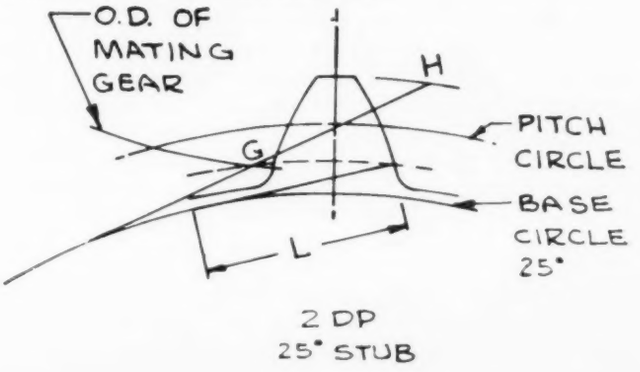


Figure 9 — The tooth of a 36-tooth, three diametral pitch pinion is illustrated, in which E–F is the line of contact action, and the radius at the lowest point of contact is K.
Figure 10 — With a 25-degree, 24-tooth, two diametral pitch pinion, G–H is the line of contact action and the minimum radius of curvature is L.



(pitch angle) stub tooth is selected and the pinions are 12-in. pitch diameter. If the teeth are one diametral pitch (Figure 7) there will be 12 teeth on each pinion. Contact on the tooth profile will extend down to the base circle, where the radius of curvature of the tooth profile is very small. If teeth of two diametral pitch are used (Figure 8) the minimum radius of curvature of the contact zone is substantially increased. If teeth of three diametral pitch are used (Figure 9) additional improvement is noted. Also, if the pressure angle is increased (Figure 10) the radius of curvature at the contact zone is increased. Of course, all design is a compromise, and extremely fine teeth will fail in bending even though surface durability is improved. Therefore, the gear teeth should be made only coarse enough to insure a comfortable balance between durability and sufficient strength to meet peak load conditions.

An increase in pressure angle increases the strength of the gear teeth as well as increasing the radius at the contact surface. Unfortunately, however, the applied forces normal to the tooth surfaces, and the bearing loads also increase with increased pressure angle. The final selection is again a compromise. The general trend in gearing is to use higher pressure angles. The $14\frac{1}{2}$-degree tooth form is obsolete except for replacement of individual gears. The 20-degree tooth form is currently the most generally used. The 25-degree tooth form is becoming increasingly popular and within a few years may well become the standard of the gear industry. Pressure angles as high as 30 degrees are occasionally used for specific purposes.

The housing, bearings and supporting shafting again are an important factor in determining what size of gear tooth is adequate. If the gear designer can be assured that the gears will always distribute their loads over their full faces, no allowances need be made for concentrating all loads in localized areas.

The trend in the design of rolling mill equipment is toward higher horsepower to the rolls while at the same time gear centers are being reduced. The gear builder must use every design improvement available in order to produce drives of improved durability as well as increased capacity.

The advantages of using package drives are many. Figure 11 shows one main advantage very clearly, note dimension X. It can be seen that the comparable separate component dimension is 1.3 times as great. This shows that a space savings is always accomplished by the use of the combined drive. First cost is often the second main advantage. Common reasoning tells us that a combined unit which has eliminated a large coupling, some shaft steel, one large bearing, various oil seals and end covers must be less expensive. However, these are not the only savings to be expected. Installation and foundation costs will be less. Also, eliminated is the continual alinement problem between reducer and pinion stand. Combination drives not only cost less than separate units but operate at reduced maintenance expense. They should be considered when selecting gear units for any complete installation.

SELECTIVE SPEED DRIVES

The field of selective speed mill drive reducers is so new in application that there are still many plant engineers who do not have an understanding of the

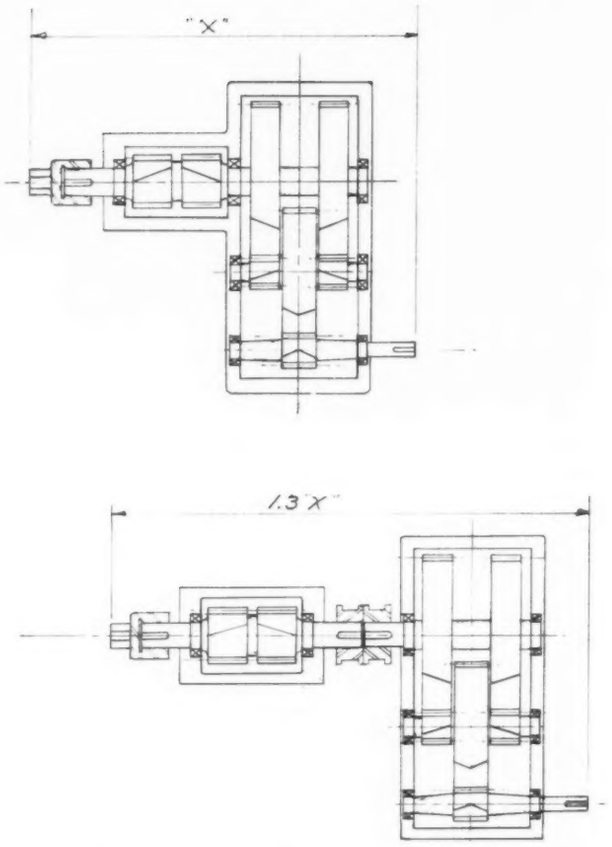


Figure 11 — The combination reducer, pinion stand unit is always smaller than a comparable separate reducer and pinion stand.

potential usage. Therefore, drive applications and some details of case construction will be discussed.

Figure 12A shows a plan that can be used for a new installation. Where a complete mill drive must be purchased, the merits of selective speed reducers can be combined in a reducer, pinion stand unit and then powered by a 1 or 2-speed a-c motor. This arrangement can produce as many as six different output speeds on a selected basis. Where a mill operation can be stopped a few seconds to shift gears, this drive serves a function closely comparable to a d-c drive. The first cost usually ranges from 25 to 30 per cent of the amount required to install a d-c motor, generator, control and single-speed reducer.

Figure 12B shows an installation of a selective speed box between an existing motor and gear reducer. This has been added with considerable success to old single-speed billet mills. Speed selection on existing mills can easily increase tonnages when rolling smaller sections. The cost of adding a change gear box on the high speed side of the gear train is very low considering the results. Figure 12C merely indicates that a selective speed reducer can be built as a reducer alone to replace any worn out or outmoded unit. In the example shown, a new multi-speed motor and selective speed reducer are connected to an existing pinion stand.

An example of some results to be expected are outlined in Table I. The table indicates bar timing in a 3-high "over and under" 16-in. roughing mill. This example was selected because it shows very clearly the possible tonnage gains.

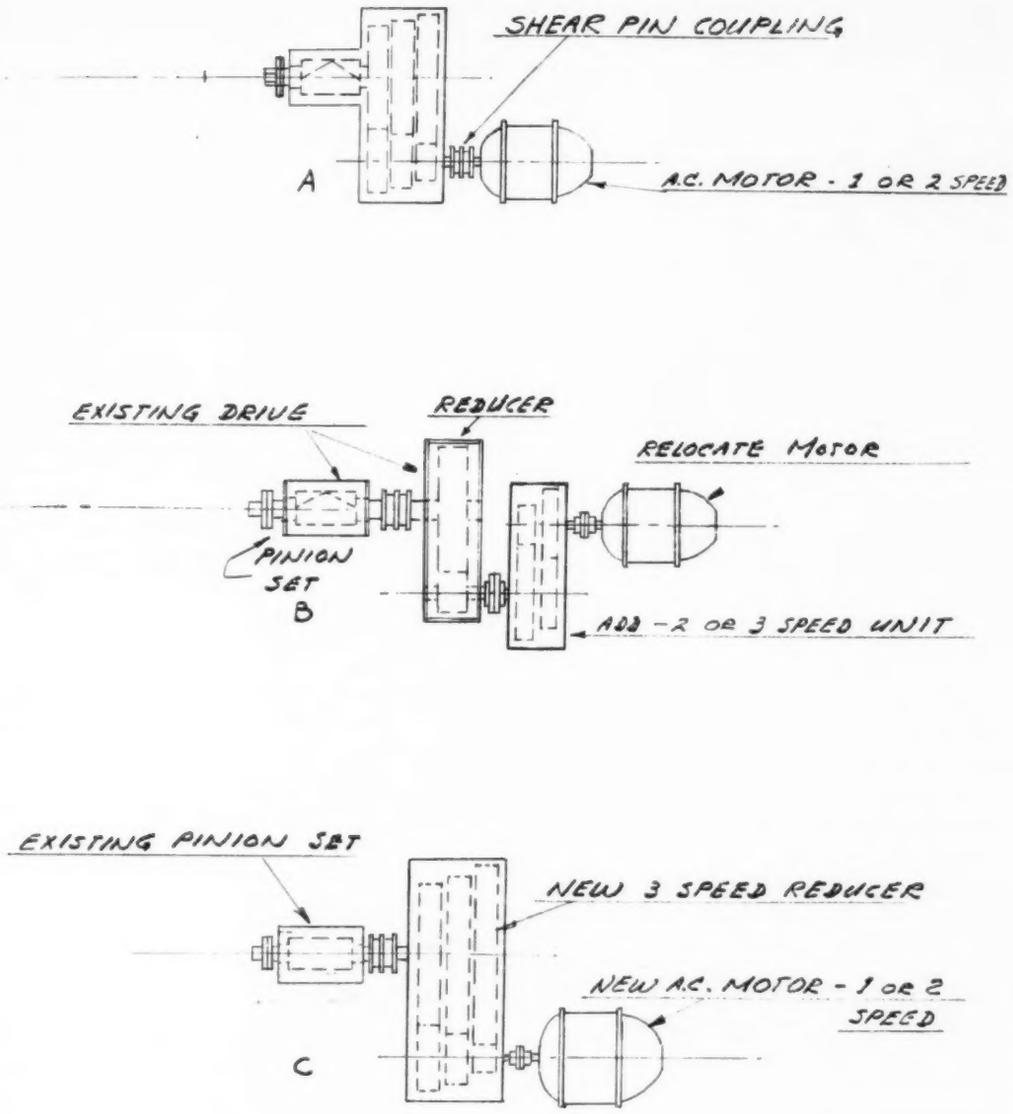


Figure 12 — There are alternate methods which can be used in a new or re-engineered installation.

The upper section shows three standard billet sizes with conventional draft reductions in five passes. By calculating the time in the mill, the output tonnages shown were determined. With a single-speed mill set at 95 rpm, yields drop sharply with relation to input billet sizes.

The lower section is charted for the same mill except that there is a selection of three speed ranges available. At the low speed of 95 rpm the 5 x 5 in. produces the same yield as the above arrangement. However, as the chart shows rolling of the 4 x 4-in. billet yields a net gain of 6.5 tons per hr, and rolling of the 3 x 3-in. billet yields a net gain of 4.2 tons per hr as related to the original mill.

For cost justification purposes a plant engineer can evaluate any existing mill drive by using this method and converting it to dollars earned by adding additional columns based upon known plant financial records.

TABLE I
Tonnage Relationships

Billet size, in.*	Weight, lb	Finished size, in.	Mill, rpm	No. of passes	Time in mill, sec	Bars per min	Tons per hr
16-in., 3-high, single-speed mill							
5 x 5	980	3 x 3	95	5	35	1.5	44
4 x 4	630	1¾ x 1¾	95	5	38	1.4	26.5
3 x 3	350	1⅜ x 1⅜	95	5	32	1.7	17.8
16-in., 3-high, 3-speed mill							
5 x 5	980	3 x 3	95	5	35	1.5	44
4 x 4	630	1¾ x 1¾	112	5	33	1.75	33**
3 x 3	350	1⅜ x 1⅜	130	5	26	2.10	22†

* All billets 12 ft long.
** Net tonnage gain = 6.5 tons per hr.
† Net tonnage gain = 4.2 tons per hr.

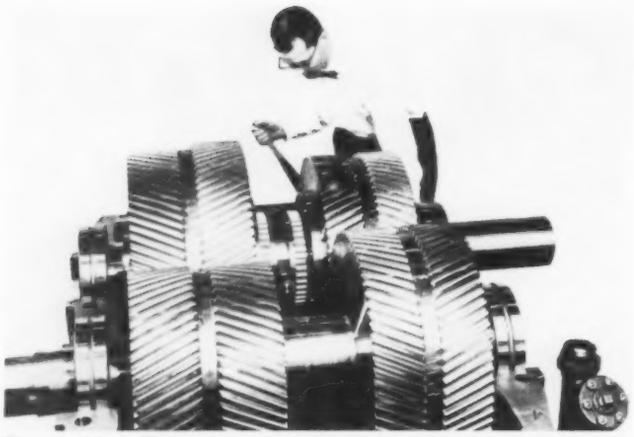


Figure 13 — Changing of the speed ratio is accomplished by sliding the spline clutch either left or right.

SUMMARY

The advantages of selective speed drives are mainly low first cost and added speed range. The disadvantages are that gears must be practically at standstill to shift, and speed ranges are predesigned rather than infinite, as can be obtained by use of a d-c motor.

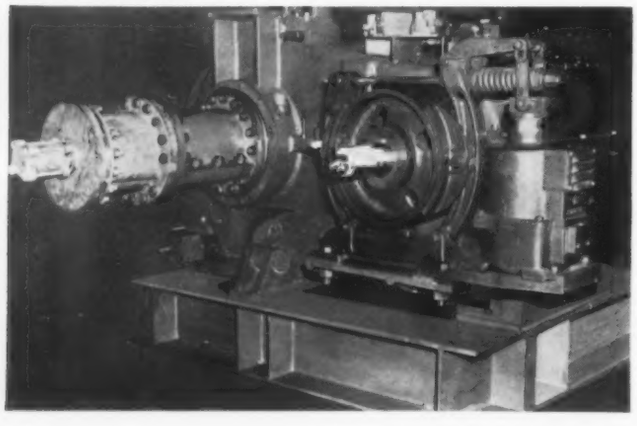
Many plant engineers are still using single-speed drives rather than variable-speed d-c drives on new installations because of the first cost of the latter. This is where the selective-speed reducer usually fits into the planning. Also, selective-speed reducers can reduce cost of d-c equipment by narrowing the required speed range.

The operation of a modern selective-speed, mill drive reducer is not unusual. The same principal has been applied to smaller drives for many years. Figure 13 shows a 1500-hp, 1 to 1 and 1.5 to 1 unit recently installed. The two input pinion gears are free running upon the input shaft. By sliding the spline clutch either right or left the desired ratio is selected. Center position is neutral, and allows the motor to run free if desired.

If rapid deceleration and remote control shifting are required, a brake and shifting cylinders are added to the system as shown. Speed changes can be accomplished from a remote control pulpit very rapidly by use of these attachments, see Figure 14.

There is much to be obtained, that is modern in construction and efficient in operation, from recent trends in rolling mill drive design. It will prove wise and profitable for plant engineers to investigate the field thoroughly before selecting gear units for any new or revised installation.

Figure 14 — Speed changes may be accomplished by remote control if desired.



Discussion

PRESENTED BY

JOHN J. STOLZ, Assistant Vice President—Engineering, The Tool Steel Gear & Pinion Co., Cincinnati, Ohio

E. C. DENNÉ, Manager, Gear Dept., United Engineering and Foundry Co., Pittsburgh, Pa.

JOHN CAMPBELL, Supervisor of Design, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

ROYAL HAWLEY, General Supervisor, Design Engineering, Seattle Works, Western Gear Corp., Seattle, Wash.

F. K. QUALEY, Chief Design Engineer, Engineering & Research Dept., United States Steel Corp., Pittsburgh, Pa.

Member: To the author's story of a pinion stand break-in run, it can be added that in order to load this pinion stand, a pair of cast pod or slipper type spindles are thrown in, with a set of eccentric backup and work rolls, mounted in worn chocks carrying questionable bearings. The mill motor is connected by cast pod or straight toothed gear couplings in approximate alinement to the input shaft, dictated by the motor bearing wear, and the position of foundations still seeking their final resting place. A handful of grease of the type most convenient is by convention thrown in the general direction of the spindles and couplings.

Thus the described clashing and vibration of pinion break-in is further aggravated by nonconstant velocity of adjacent torque transmission elements, which each in this chain, add or subtract their various harmonics for questionable break in of certain random pinion teeth or contours. This situation is often present with related adjacent links and ignored in connection with precision pinion stands.

The author's comment on shear pinion couplings between the motor and the drive is feasible only if such couplings are diligently selected for convenience of shearing member replacement, and provision of systematic inspection. To provide protection at a practical torque level, the shear pin stresses must of necessity be high and thus are subject to fatigue by a series of lesser shocks. This problem can best be met by designing for ease of inspection, that is inspection after each major wreck. If the pins are the least bit distorted, they should be replaced. Replacements of shear elements upon any signs of failure and co-ordination of periodic replacement dictated by the mill operating load and the product mix are intelligent preventive maintenance items.

With well designed pinion stands and reducers, one link in this chain is strengthened. Others remain which must also be eliminated to provide a smooth torque transmitting system of uniform strength.

Selected speed drives have good characteristics which can be utilized to economically meet certain requirements. Compared to a-c variable-voltage drive with constant torque, the change gear selector base torque

can be multiplied in direct proportion to the increased ratio. This method provides greater proportion to the increased ratio. This method provides greater torque for the heavier drafts to meet the mill cubic constant.

John J. Stolz: It is felt that the opening remarks are probably somewhat exaggerated regarding the break in of early gear drives.

First off, it is true that in the early days of mill construction it was not uncommon to find 11 and 12-tooth mill pinions having a circular pitch as great as 5 in. It was necessary at that time to have large circular pitch pinions to carry the loads required as good gear materials were not as widely available in those days. A lot of these pinions were produced from castings with the teeth as cast. Noise and vibration were serious and short wear life predominant.

As far back as 1926 our company policy has been upon receipt of any inquiry or order for this type of gearing to at once request speed and load data. Then gear calculations are made and a new set of cut teeth pinions with more teeth and finer pitch are designed. This redesign is recommended to the customer. These pinions are produced in carburized and hardened alloy material with the journals hardened and ground and with hard wobblers. These pinions do not require the black oil break in and sand mentioned earlier. Wear life records show up to 8 to 12 years per set with bearing life either in babbitt or bronze being extended tremendously. The greater number of teeth and the finer pitch produces pinions with a low noise level and with vibration held to a minimum.

It is felt that 12-tooth pinions should never be used in any application, if at all possible. However, with herringbone pinions fewer teeth are necessary, to get good tooth form, than when using regular spur pinions. The tooth shape that a herringbone pinion will have is determined by dividing the actual number of teeth by the cosine of the helical angle cubed. This will give the number of teeth in the normal plane and determine tooth shape. For example, a 12-tooth herringbone pinion having a 30-degree helix angle will actually have the shape of approximately an 18-tooth pinion. Under the circumstances, approximately 17 or 18 actual teeth should be considered as a minimum for any of the herringbone mill pinion stands.

Many pinions produced today have 20-degree stub teeth. Bearing pressures do increase with increased pressure angles. In comparing a 20-degree pinion with 25 and 30 degree pinions, it is found that a 25-degree pinion increases the bearing loading by about 2.9 per cent and a 30-degree pinion increases the load on the bearings by 8.1 per cent.

Continued recommendations will favor the 20-degree gearing, going to the 25-degree pressure angle only as required for special high-load applications.

Carburized and hardened alloy steel gearing with the hardness ranging to approximately 650 Brinnell for any of the present and future designed mill stand gearing should be recommended. This type of gearing will work very well on present and future mill stand gearing.

E. C. Denné: The combination drive and pinion stand has several advantages over the separate drive and pinion stand. It is more compact and eliminates the use of a large low speed coupling.

Like any other gear drive, it has its limitations. The most critical one is the use of a third bearing between the mill pinion and the gear to reduce the shaft deflection. This presents a bearing problem to determine the division of load on each bearing in a continuous beam of three supports. To be sure there have been some in operation for 30 years or more with good and bad performance records. Small work rolls and short spindles automatically determine the mill pinion centers. It is, however, good practice to increase the pitch diameter of the pinions, and decrease their face to obtain a good 2-bearing assembly. The space saved, by eliminating the middle third bearing and the reduction of pinion face, can be added to the mill spindles in order to keep their angle within practical limits without increasing the over-all floor space. The larger pinions provide more space for adequate bearing mounting and in addition decreases the bearing loads. Heavier pinion teeth can also be provided, within reason, to offset tooth breakage.

Speaking of large teeth, spare gears and pinions of 7 and 8-in. circular pitch are still being cut. Many of these large pitches are handed down from the cast tooth days, and will not be changed until some of the "old timers" pass out of the picture. On the other hand, wherever and whenever possible, the old designs are being made obsolete by new recommendations.

With respect to a choice of pitches, it is good practice to make the selection so that the teeth are amply strong, yet sufficient of numbers to give smooth wear life. There are times when low numbers of teeth (i.e., 14) of 20-degree stub design are specified in a mill pinion. When this is the case, the pressure angle should be 25 degrees or more, and the helix angle high enough to get adequate helical overlap.

All the higher pressure angles can be generated with standard 20-degree stub cutters by simply decreasing the number of teeth in a standard gear set, or by increasing the center distance, both amounting to the same thing. This means that a less sensitive part of the involute curve is being used. The top land of the teeth will be less, and the root thickness will be greater for the higher pressure angle, thus greater wear life and stronger teeth will result. The higher pressure angle adds very little to the bearing load, about one per cent per degree rise.

John Campbell: On 5-stand cold reduction mills, the trend toward larger diameter rolls causes problems electrically to provide as much acceleration and deceleration as needed. In addition to the increased inertia of the work rolls and backup rolls, there can be expected an increased WR^2 for the spindles, gear drive and motor or motors. When it is said that the gear builder must use every design improvement to produce drives of improved durability and increased capacity, the statement is in harmony with the mill designer's need to find drives capable of transmitting larger horsepower without in themselves adding to the inertia of the system.

Can the gear industry help matters by keeping the weight and the inertia of the gear drive down, by using better materials and new designs?

In severe service applications, such as cold reduction mill drives, the statement, "no gear set can be any better than the housing in which it is carried," seems to be especially true. Even with modern equipment, there is not perfect balance of rotating parts, and some vibration is transmitted through the bearings to their seats

in the drive housing. Impact conditions, such as occur when a strip enters the mill or when a wreck occurs, also tend to pound the anti-friction bearings of the drive unit into the housing seats. In some cases, it has been necessary to bore out these bearing locations and place hardened steel inserts in the housings. Is this a common problem and are hardened seats for anti-friction bearings provided in drives designed for severe service applications?

Royal Hawley: Gear drive manufacturers have been forced to produce more output torque capacity per unit of WR^2 by the constant demands for more gear capacity in smaller center distance drives. The combination unit is especially favorable in this respect since the shaft extensions and coupling between reduction gear and pinion stand are eliminated.

When reduction gears are used the largest percentage of inertia of the drive is in the input pinion, shaft and motor coupling. If low WR^2 is a design requirement then the mass of these parts should be reduced as much as possible, and the input shaft should be designed for high stress level.

With respect to the problem of anti-friction bearings pounding out their housing bores, this has not been found to be a problem if the bearings have been properly selected for capacity, and have not been loosely fit in the bores at initial assembly.

Occasionally bearings are mounted in adapters if an especially tough service problem exists, but this practice is not usually followed.

F. K. Qualey: Gear drive design is becoming more critical, and power and speed requirements for rolling mills are constantly rising. Gear drives for high-speed cold mills and finishing train drives of high-speed rod mills can spell success or failure for the finished product.

Rigidity of housing, bearing type and mounting, selection of gear tooth form and method of lubrication should be thoroughly analyzed for all mill drive gearing early in the design stage.

Royal Hawley: A mill system is a complete train, and the pinion stand alone cannot be considered in isolation to that complete train. Uneven rolls present a condition that is exactly analogous to the torque testing of reduction gear boxes that gear manufacturers use. It is this problem of considering the complete power transmission system that is leading the manufacturers to look at the other elements in the drive, such as the spindles and the mill stands, for some of the mill users will not look at them.

Would Mr. Stolz explain the matter of numbers of teeth, tooth form and herringbone pinions again? When the tooth form in the transverse plane is considered, it is a section of the tooth and no one cares whether it is a portion of a herringbone or a spur gear. When there are a small number of teeth, if the pressure angle has not been increased either by using 20-degree tools and dropping teeth, or by using high pressure angle tools, the machining will be in the undercut range of the tooth.

There are conditions which can arise in a set of specifications, combinations of reduction ratio, center distance on the pinion stand and power requirements, which make it virtually impossible to put together a combination unit that will be correct and proper.

There must be room for a sufficient third bearing in the center of the shaft and the stress analysis of the shaft assembly must be correct so that the situation of the usual indeterminate stress in that 3-bearing setup is known. It is very nice also to wish to increase the center distance on the pinion stand in order to use narrower gear faces. Unfortunately, in many instances this point is where the roll designer does not wish to cooperate, for he wants to reduce the center distance to six in. and then transmit 3000 hp through the stand.

Whether 20-degree tools are used and teeth are dropped out of the train, or whether hobs that have a 25 to 30-degree rack form are used, the result is the same. Tools designed for 25-degree pressure angles are being more widely used because a better job can be produced with them than with the 20-degree tools for the same gear.

John J. Stolz: The statement was that the number of teeth from which the profile is derived is to use the actual number of teeth and divide them by the cosine of the helical angle cubed. That will produce the tooth profile that the teeth will have on the normal plane, and in doing this a larger than normal pitch diameter is obtained. If a larger than normal pitch diameter is obtained with the combination of the larger number of theoretical teeth and the normal circular pitch, the undercutting is automatically eliminated in the low number of the teeth in the transverse plane.

Royal Hawley: Would not this be a higher transverse pressure angle rather than a higher number of teeth?

John J. Stolz: Theoretically the number of teeth increase for normal pitch diameter is figured by using the normal number of teeth. The normal number of teeth does not come out as an even number. To figure the normal pitch diameter, that is the pitch diameter on the normal plane, the normal number of teeth times the normal circular patch, times 0.3183 is used. The actual tooth profile is then developed on the normal pitch diameter.

It is a very simple matter to go through the formula and lay out the teeth. While one may start with 12 teeth in the transverse plane, the tooth form will be for a larger number of teeth when looking at the tooth form in the normal plane.

Royal Hawley: In talking about normal pitch as against transverse pitch, when a 20-degree hob is used in the normal plane to cut a herringbone or a helical gear, the pressure in the plane of rotation will become about 21 or 22 degrees. The profile is that which would occur from a 16 or 17-tooth pinion, the pressure angle has been increased.

John J. Stolz: A tooth form on the normal plane is obtained that is actually the form of a larger number of teeth.

Royal Hawley: We cannot agree with this.

John J. Stolz: It is suggested that a layout be made developing the tooth form on the normal plane.

Member: In the larger mills the trend is to use seamless high-strength tubing shafts in place of heavy shafts. Size can come down in proportion to the torque transmitting gain made by use of better materials.

The old established practice has been to use straight teeth and nonheat-treated castings for the larger couplings. By using heat-treated alloys and eliminating the flanges, a direct WR^2 gain is made, which in turn gives a more responsive mill. ▲

Epoxy Resins Aid Steel Plant Maintenance

by ELMER E. BARTHEL, Assistant Superintendent, Maintenance
Pittsburgh Steel Co., Monessen, Pa.

. . . . numerous types of epoxy resins can be used for a wide range of patching applications and may give greater service life than the original material . . . . handling instructions should be closely followed as some individuals are affected by the toxicity of the epoxies. . . .

THE word epoxy comes from the Greek, epi, meaning over or between the English, oxy, for oxygen; therefore, it means "oxygen between," referring to a molecular grouping of carbon and oxygen. Castor oil actually contains this epoxy grouping. Epoxy resins are primarily produced from a coal tar derivative called bisphenol-A and a product formed during the manufacture of synthetic glycerin called epichlorohydrin.

Undoubtedly the most valuable property of epoxy resins is their ability to transform readily from the liquid state into a tough hard solid. This hardening is generally accomplished by the addition of a chemically active reagent. Therefore, most resins are packaged as 2-component systems. The action causing the hardening may occur immediately upon mixing of the two components, the actual "set" will require from two min to 12 hr, or at some later time induced by the application of external heat.

Some of the physical properties of bisphenol-A casting resin include: a tensile strength of 8000 to 12,000 psi, a compressive strength of 15,000-psi yield to 30,000-psi ultimate, a flexure strength of 18,000 psi, a modulus of elasticity for tension compression and flexure of from 400,000 to 600,000, a shear strength of over 12,000 psi on a steel to steel bond and very little shrinkage on cure. It is self extinguishing when subjected to flame. These physical properties can be greatly increased by laminating with fiberglass or using fibrous fillers. Because glass fibers have excellent physical properties and epoxies are capable of forming an excellent bond to glass, a fiberglass epoxy laminate is a natural combination.

Such a laminate properly made will have a tensile strength of from 40,000 to 60,000 psi which on a strength to weight ratio exceeds steel. The chemical properties vary with the curing agent used and the degree of cure. The end result can also be varied by the use of different hardeners, to produce almost any degree of flexibility in the final product. Most epoxies are extremely resistant to all but the strongest oxidizing acids, most caustics and most solvents, once they are properly cured. An unfilled epoxy is a very good insulator having a dielectric constant of 3.8, the constant for air is 1. Resins have a dielectric strength of 425 volts per mil on a sample 0.125 in. thick. One of the drawbacks of the epoxies are their low heat distortion point. Many tend to distort as low as 200 F while some special formulations can be used as high as 450 F, and continued research may raise this yet higher. However, at these higher temperatures, after prolonged periods of time, crazing and cracking may occur which allow moisture to invade the coating. If the epoxy has been used for electrical insulation, this can be very detrimental.

Rather than go into the many uses of epoxies, and they vary from paving roads to filling teeth, a few of the uses to which they have been put and some of the results will be pointed out. As a patching material it has been found that a thixotropic material used with fiberglass as a laminate or a fibrous putty are best. As would be expected the larger the lap of adjoining material the stronger the job. With a leaking pipe, where it is possible, the pipe is completely encircled. In order to test this usage a ½ x 3-in. slot was cut in a 3-in. piece of pipe and then patched with an epoxy fiberglass laminate. This pipe was tested after curing to over 1000 psi with no sign of weakening. One of the biggest jobs attempted involved patching a portion of the dirty gas main between the dust catcher and the gas washer on the No. 3 blast furnace. On an elbow from a vertical leg, the high-velocity dust particles had eroded a hole in the main and blast furnace gas was creating a hazardous condition in the area. As is usually the case, the furnace was in a critical position as far as production was concerned and the delay necessary to weld a plate on the line had to be avoided if at all possible. A temporary patch using a toggle plate was tried, but after several hours of operation it proved unsatisfactory. It was decided to patch the main with an epoxy fiberglass laminate. The line was purged, the toggle plate loosened, fiberglass and epoxy worked under and around the plate and the plate retightened. Epoxy and fiberglass were used to seal around the plate and after a total elapsed time of 45 min the line was placed back in service. This patch held over a week, during which time the necessary preparations including bracing of the

line and forming of the plate were made for a proper welded replacement. If another repair such as this was to be attempted, the toggle plate would be removed completely and only fiberglass epoxy laminate would be used. Another place where laminates have been successfully used for patching is in the acid cleaning tubs on the wire galvanizing lines. These tubs are made of hard rubber and contain a solution of 6 to 12 per cent muratic acid. One of these tubs had developed about a 6-ft longitudinal crack. The tank was drained, rinsed, dried and the area around the crack was wire brushed to obtain a suitable surface; then a single layer of glass cloth with epoxy was applied. This tank has been in operation for over six months with no apparent cracking or attack by acid. A second tank was patched with the same results. These laminates are examples of what can be done and the materials which can be used. Epoxies filled with aluminum for heat conductivity, silicon carbide for wear resistance, cotton flocking for build-up and strength and sand for an inert filler have been used.

In putty form, epoxy has been used to fill small cracks and holes. An example of this was a leaking transformer in the blast furnace area. The fact that the leak was on a flat surface on the tank made it especially easy to patch. The surface was wiped clean, sanded and wiped again; then a ball of epoxy was placed over the leak and a piece of wood was pressed against the epoxy and blocked in place during hardening. This cure worked in spite of the fact that the area still had a film of oil present when the epoxy was applied. With a similar putty like epoxy, the flanges on two high-concentrate acid tanks were sealed. These tanks, used to store sulphuric acid at 66 Baume, had developed leaks at the bottom flanged connections. The tanks were drained one at a time, the flanges removed and all surfaces cleaned. The eroded portions of the tank and flange including the bolt holes were filled with epoxy. The bolts were then forced through the flange holes and the whole section pulled into place forcing the epoxy to fill all voids. This has completely eliminated the leaking and it is felt that, if necessary, this flange can be removed by heating it sufficiently to soften the epoxy bond.

The second major repair made with epoxy involved its use as a filler. One of the pump casings from a 15,000,000-gal river water pump had washed out. This washout is due primarily to erosion caused by fine silt particles traveling at high velocities. Prior to this time these cases had been built up by brazing; however, this was costly and did not wear well. This time the largest washouts were filled with heavy epoxy, then the entire inner surface was coated with a thinner epoxy. This pump was placed on the line October 4, 1958 and taken off 18 months later due to reduced operations. There was some cracking noted in the painted layer but no appreciable wear as had been experienced with the castings. This compared with a life of 24 to 30 months for a new case. A similar repair was made on a ball check valve in the blast furnace slurry pumping system. Again there had been trouble with erosion due to fine particles of ore flowing as a suspension in water. The washed out portions were filled and the entire valve was coated. This has proved equally successful.

The third category of epoxy uses covers coatings. Here one capitalizes on the chemical and wear resistance of epoxies. In 1959 there were between 10,000,000 and 12,000,000 lb of epoxies used for this purpose in the U. S. One use involved the forementioned river water pump casing which was coated after having been filled. The cracking mentioned was found to be due to the use of too rigid a material. This has been corrected by utilizing a more flexible epoxy. The new plate welded on the blast furnace dirty gas main patch was also coated. As yet it has not been possible to inspect this patch to determine the effect it has had on wear. The inside surface of a few precipitator collecting tubes have been coated where the stainless steel weirs join the mild steel tubes. This has a threefold purpose: (1) it presents a smooth surface for good gas flow with no sharp edges for electrostatic erosion; (2) it prevents moisture from reaching the joint of the dissimilar materials preventing electrolytic erosion; and (3) it presents a very smooth surface to which dirt cannot cling giving a better wash action to the tube. The wearing surface on the old sinter plant mixer was also coated. Normal experience is to patch after about one year's service, but after ten months there is no apparent sign of wear.

The fourth use for epoxies is as an adhesive. The epoxies have outstanding bonding strengths even to very smooth materials. Their high shear strength, as high as 12,000 psi on steel to steel, puts them in a category to compete with rivets or welds. One experience with epoxy was a demonstration showing it joining two pieces of glass. The glass, $\frac{1}{4}$-in. plate, broke before the bond broke. Epoxy has been used to glue relays, broken contactors and even electric insulators with no difficulties. The biggest usage involved the installation of a new sluice lining under the hot strip mill at the Allenport plant. In order to do this job the sluice was gunnited back to its original contours, then epoxy was used to cement basalt-like material into place. Here again the fast setup time and its ability to fill any voids which might occur between the basalt and the concrete made epoxy the ideal material. Approximately two tons of epoxy were used on this job.

The fifth and last category in which epoxy has been used involves its use as an electrical insulator. The most familiar use is as a potting or encapsulating material for coils or windings. It has the ability to keep water out, provide good heat transfer and be chemically resistant to attack. Pittsburgh Steel Co. has not actually used epoxy for this purpose, though it has been used to patch V rings on small motors and to fill the risers on the blooming mill motors. It is felt that epoxy will be used as a seal against moisture on motor windings but no extensive tests or investigations have been made.

All of the applications mentioned were successful: there have been some failures. An attempt was made to coat an aluminum impeller, but due to the dirty pores in the casting, a bond could not be obtained. Also, an attempt to paint water lines under the acid tanks was unsuccessful. It is felt that insufficient preparation prevented this from being successful.

Epoxies also have some shortcomings: they are toxic to some people and the preparation necessary often prevents their being used or, if they are used, insufficient preparation often prevents the successful completion of the job. ▲

What Maintenance Does the Sinter-Plant Designer Expect?

by J. H. PORTEUS
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. . . . changes in operational factors such as per cent of capacity loading and raw materials can greatly affect sinter plant maintenance. . . .adverse effects can be reduced with a realistic maintenance program. . . .

PRIOR to answering the question posed by this article's title, a few general comments should be made. First, operating must be considered. No one expects that a plant will be run below its rated capacity, not even its maintenance superintendent. On the other hand, if a plant is consistently operated at 150 per cent or more, of its designed capacity, then heavy wear and high maintenance costs are to be expected.

Usually, by agreement between the designer and the purchaser, a sinter plant is designed to produce up to 20 per cent more than the rated or guaranteed capacity; therefore, the designer expects that the plant will be operated at between 100 and 120 per cent of rating. If the purchaser knows that he can use more production, and thus hopefully expects to run his plant at 130, 140 or 150 per cent of rating, he can of course do this. It is felt, however, that over the life of the plant total costs will be definitely lower if a plant of capacity adequate to the heed, as reasonably anticipated, is bought. It is hard to prove conclusively exactly how much lower maintenance costs would be with adequate as against overloaded equipment. It is certainly true that additional capacity (within reason) can be purchased quite cheaply in the design stage, whereas the cost of later changes may be prohibitive.

The reputation of a plant designer rests on the cost and performance of his plants, thus he is vitally interested in maintenance, and will honestly try to furnish equipment which, at the designed production of 120 per cent of plant capacity, will operate in a load, size or speed range that will give good service with reasonable maintenance. However, as long as sinter plants are bought on competitive bidding, he cannot afford to design in the extra capacity which would enable the plant to be operated at still higher ratings (within the recommended ratings of all equipment). The best possible plant, on paper, is of little use if it cannot be sold.

Assuming then that the sinter plant capacity is reasonably matched to the operating rate, what maintenance does the sinter-plant designer expect? He expects that the recommendations of the equipment manufacturers will be followed; that a program of continuous inspection, lubrication, adjustment and repair or replacement (preventive maintenance) will be carried on; and that good housekeeping will be maintained. A practice which appears to work well is:

1. The inspection and lubrication programs are carried on continuously, plant wide.

2. Clean-up, adjustments and minor repairs and replacements are carried on daily, plant wide, following the inspection check lists which locate them. Examples are conveyor transfer points, belt scrapers, idlers, feeders, etc.

3. Major repairs or replacements, where practical, are also carried on through the week. This applies to all equipment, outside the sinter machine building, which runs one or two turns daily, and to stand-by equipment in the sinter machine building. Examples are rod mills, car dumpers, screens, shuttles and trippers, pug mills and the limit switches, contactors, rheostats and other electrical gear associated with such equipment.

4. A program along these lines permits the maintenance force to be utilized efficiently at all times, and allows it to be concentrated in the sinter machine building during the weekly or 10-day downturn. It is of course assumed that service record files, together with complete inspection reports, are kept on all major equipment, so that all known or anticipated repairs and replacements can be planned for and scheduled in advance.

It is not proposed to go into details on the maintenance of various equipment. However, a few comments here might be appropriate. For instance, there have been rod mills in which some of the charge rods had been allowed to wear down to $1\frac{1}{4}$ or 1 in. in diameter, and were consequently breaking up and coming out of the mill in pieces. Such pieces have torn conveyor belts, blocked chutes and gates and jammed breakers or other equipment.

Vibrating screens are sometimes improperly lifted and handled, burning torches are used on them and screens (particularly hot screens) are run with loose bolts and even loose trough plates. Screen experts say that exciter failures have been traced to things such as:

1. Carelessness in allowing dirt to drop into the exciter when checking or changing oil.
2. Failure to clean magnetic drain plugs.
3. Failure to use proper oil.
4. Failure to maintain proper oil level.

Other bad practices which have been seen include: machines running out of alinement; dust allowed to accumulate to the point where conveyor idlers and pulleys were partially submerged in it; conveyor belts tensioned too high and unevenly; conveyor belts riding against chute sides and cutting their edges; and bearings being replaced in dusty and dirty areas (not in an emergency).

The plant designer feels that failures occurring from causes such as the foregoing can be prevented, that is, they should not occur. On the other hand, he realizes that bad practices are not always the fault of the maintenance dept. In some plants, the maintenance superintendent does not get the cooperation of the operators for necessary shutdowns. In others, he is not given a budget adequate for the kind of job that should be done. And sometimes mill seniority or other factors prevent his getting competent men that can be trained and depended upon.

As to the effect of the plant design on maintenance, being human, the designer makes errors too. Sometimes a piece of equipment which has worked well in a different application, or in a pilot plant, does not perform in service as expected. Sometimes an arrangement of a particular piece of equipment, or subprocess which looked good on paper, does not work out well, i.e., where spillage is much more than anticipated, requiring constant clean-up, and the clearances or head room are so limited that not much can be done about it. Also, under the pressure of turning out construction drawings to get a plant built, sometimes inadequate provisions are made for access and working space around critical equipment. However, here again poor results may not always be the designer's fault. At times customers have forced him to provide equipment or arrangements which he does not recommend, and at other times changes in plans have meant that plant or equipment have been operated in a manner different from that anticipated.

In any event, since good practices as well as bad have been described, this is not a mere catalog of the latter, but rather an attempt to point out that improvement, from all angles, is both possible and needed. This is the important point. Some plants are doing an outstanding and continuing job of improving their maintenance practices. In turn, designers are continually visiting operating plants, observing, asking questions and looking over records, to see how and where they may do better next time. ▲

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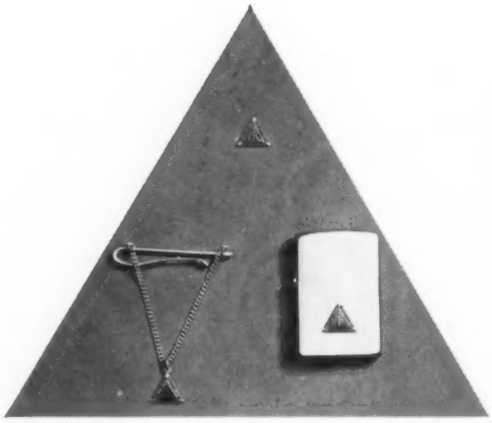

ASSOCIATION OF IRON AND STEEL ENGINEERS

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Techniques in Rebuilding Open Hearth Furnaces

by CARL F. BESSENT
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. . . . while preplanning and prescheduling are important factors, and maximum mechanization of teardown and rebuild is necessary, co-ordination during the rebuild allows proper direction and utilization of personnel regardless of the difficulties experienced. Continual co-ordination permits the completion of the rebuild in the shortest possible time and with the least misdirection of craft labor . . . .

A MAJOR portion of the cost of steel plant operation involves the materials and labor required for the lost production resulting from furnace repairs. The maintenance of open hearth furnaces is the largest factor in this cost. A basic requisite for successful open hearth operation is extended furnace life and shorter repair periods. Recent improvements in open hearth furnace design and materials stress the importance of proper and efficient furnace rehabilitation.

The production of steel from iron, scrap and various alloys in an open hearth furnace is by no means a new process but in the past 15 years much has been done to increase tonnage and lengthen furnace life. An open hearth shop is shown in Figure 1.

After 200 or more heats, depending upon furnace design, refractories characteristics and operating techniques, it becomes necessary to shut the furnace down for rebuilding. In approaching the problem of rebuilding rapidly and efficiently, the main areas of work as shown in Figure 2 are: (1) furnace ends, consisting of port roof, end above charging floor, uptake and slag pocket; (2) main roof and hearth, including hearth, front wall, back wall and roof; and (3) regenerator area, comprising fantails, checkers, regenerator roofs and walls, flues and backsewers.

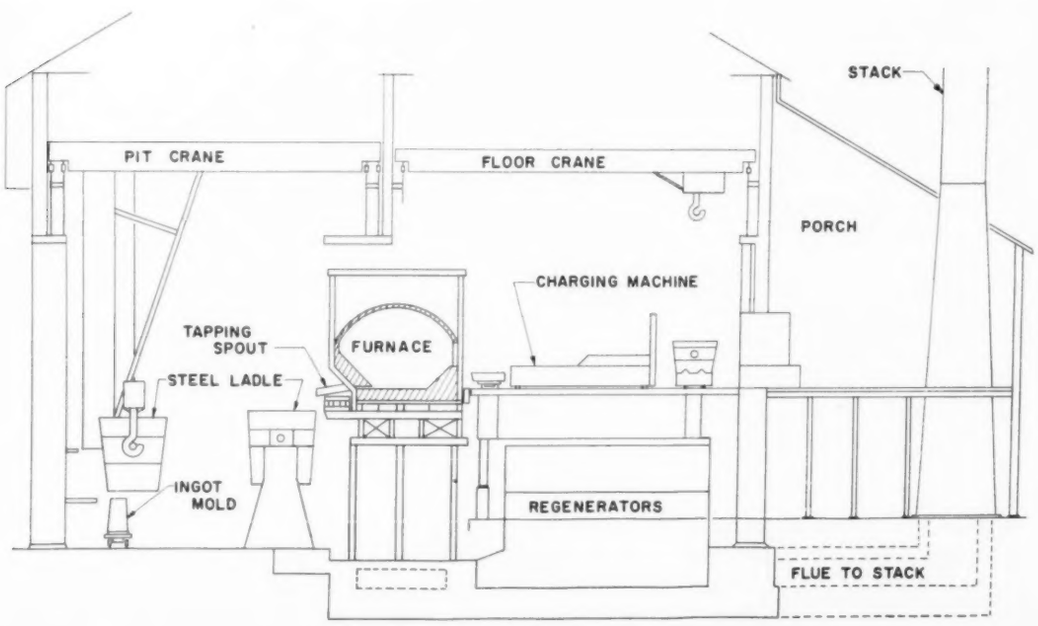


Figure 1 — Cross section through the open hearth shop illustrates the general equipment layout.

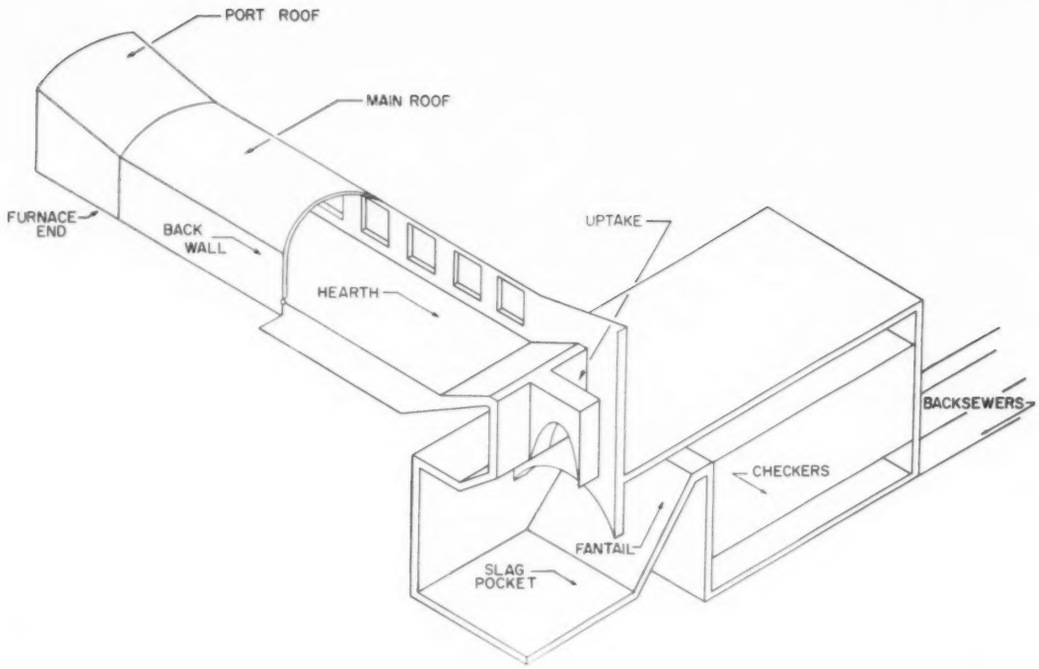


Figure 2 — The main work areas involved in a furnace rebuild are shown.

At the Sparrows Point plant there are 35 open hearth furnaces divided into four shops. No. 4 shop, with seven furnaces each of 375-ton capacity, is the most recently constructed shop and this article is concerned, primarily, with the rebuilding of these furnaces. In dealing with rebuilds on smaller furnaces, the same methods are employed but because of the relatively smaller dimensions, the need for special materials and equipment is minimized.

In addition to being limited to dimensionally larger furnaces, this article deals with general rebuilds in which maintenance of all furnace areas is performed rather than "hot patches" or "roof only" repairs in which no work is done below charging floor elevation.

SCHEDULING AND PLANNING THE REBUILD

Advance notice of anticipated rebuilds is vital to maintaining furnace operation at maximum availability. Open hearth operating supervision publishes a tentative 6-months repair schedule which serves as a general guide to forthcoming rebuilds. Under full operation, when it is advantageous to obtain all possible production from each furnace before rebuilding is necessitated, the scheduling of rebuilds is a function of four factors:

1. Campaign length.
2. Time required per rebuild.
3. Rebuild force availability.
4. Planning, co-ordination and proper application of repair forces to rebuilds by responsible supervision.

Careful study of records of campaign length and time required for rebuilds determines the frequency with which rebuilds should be started. If rebuild times lag or campaign lengths decrease, rebuilds must be scheduled with greater frequency. If rebuilds are allowed to lag, excessive shutdowns for patching will be required or simultaneous rebuilds will occur without benefits of planning.

Planning for coming furnace rebuilds is consolidated in a weekly meeting of operating and maintenance supervision. At the meeting, a job list is made on all furnaces nearing the ends of their campaigns. In order to properly plan the rebuild, the following sources of information are used to predict the work requirements:

1. Records of the conditions and ages of the various components as noted on previous rebuilds.
2. Reports of operating difficulties as noted by operators, which will require corrective action during the rebuild: bad bottoms, blocked regenerators, faulty mechanical equipment, etc.
3. Observations of inadequate brickwork as noted during hot patches late in the campaign.
4. Findings of inspection of furnace structure and equipment made by mechanical forces late in the campaign.

After consideration of the work known to be necessary during the rebuild, a tentative "line-up sheet" is made so that all crafts involved in rebuilding may prepare equipment and schedule forces to promote completion of all required work in the shortest possible time. At the meeting, the day and approximate hour of the last tap is decided and a tentative schedule of the rebuild is agreed upon. Methods of scaffolding and material handling are decided upon, and if several major jobs are all to be done in one specific area, a sequence is determined so that no single job will "block out" other important work and lengthen the rebuild. Line-ups of three or more furnace rebuilds are made each week so that co-ordination and planning will be simplified if conditions dictate a last-minute change in order of repair.

REBUILD PROCEDURE

Preparation for rebuild—In the last two weeks of the furnace campaign, preparations are made which will facilitate rapid completion of the rebuild. The

height of slag in the slag pockets is determined and blast holes are drilled into the slag at the desired locations and to the desired depth. The 3-in. diameter holes are drilled in silica slag by a pneumatic wagon-mounted percussion rock drill with carbided heads. For basic slag, a track-mounted pneumatic rotary drill is used with a diamond inset coring bit. Basic slag, found in slag pockets of furnaces where basic brickwork is used on the furnace end presents drilling problems due to its nonhomogeneous gravel-like composition. Blast holes drilled in basic slag have a tendency to lose their shape and collapse during and after drilling. The problem of collapsing holes has best been solved by insertion of a sheet metal "stove-pipe" into the hole immediately after drilling. No difficulties are encountered in drilling silica slag or in maintaining holes after drilling. After drilling, pipes are inserted in the blast holes and air which is blown through the pipes cools and cleans the holes. The same pipes are used to water cool the holes for eight hr before blasting. Replacement piping, structural assemblies and mechanical parts are, as much as possible, prefabricated and brought to locations accessible to the furnace. Tools and scaffold components are prepared for use and positioned near the furnace: mobile cranes and other equipment are readied for use. Rebuild forces must be properly equipped to service themselves with minimum dependence on the operating unit. Refractories, lumber and other rebuild materials to be used are brought as near the job site as operation requirements will permit. During the working of the last heat, angles and bars which retain furnace end brickwork are burned through to expedite demolition.

Removing furnace from operation—After the last tap, operating crews ordinarily spend less than one hr "making bottom" before fuel may be removed from the furnace. As a safety precaution no stripping or demolition of the furnace is done until blanks have been installed in the gas lines and the liquid fuel lines have been disconnected. As soon as fuel is off, the fuel lines are steam purged.

As soon as the fuel lines have been purged and the furnace is in safe condition, dismantling and demolition begin. To minimize flying brick and slag from the blasting operation, blasting mats made of used conveyor belting are hung in front of the slag pocket seals. In the charging area, doors and frames are stripped from the furnace. Water streams are played on the underside of the main roof to cool the roof to promote rapid removal of rubble after the roof is dropped into the hearth. On the ends above floor level, teardown of brickwork is started. At regenerator level, checker seals are pulled and cooling mist sprays are placed on top of the checkers. Furnace dampers are positioned and fans are placed at strategic locations to promote rapid cooling of flues and checkers.

Furnace ends—Of the three major work areas involved on an extensive rebuild, the furnace ends ordinarily require more time to rebuild than either the main roof and hearth or regenerator area and, as a result, co-ordination of forces and employment of time-saving techniques are of primary importance in demolition and rebricking the ends. The furnace end is composed of the port roof, end above floor level, uptake and slag pocket. As soon as the fuel lines have been purged, it is essential to a fast rebuild that slag removal and brickwork teardown be accomplished with the least possible delay.

Removal of slag from the open hearth slag pockets is accomplished by blasting predrilled holes followed by loading out with mechanical equipment.

The positions and depths of blast holes are determined by the pattern of the slag within the slag pocket. Silica slag maintains a level surface within the pocket and slag height increases as the campaign progresses. Basic slag, however, does not level itself but forms in a pattern with high slag on the outside pocket wall and less depth at the inside wall. Before drilling, a few seal brick are removed to determine slag height and distribution and then the holes are marked off and drilled. The depth to which the holes are drilled is also controlled so that effective charges will be placed in the heaviest concentrations of slag. Care must be exercised in drilling and blasting to keep structural damage to furnace components to a minimum. It may be expected that repetitive blasting of slag pockets will result in furnace damage, especially to slag pocket buckstays.

An ammonium nitrate blasting agent, packaged in 1-lb cans, is used in slag blasting. In order to determine the amount of explosive to be used, the height of slag in the pockets is again measured and the volume of slag estimated from these measurements. By application of the ratio of one can (one-lb) to 2.7 cu yd of slag, the number of cans to be used in each pocket is derived. The cans are distributed among the various holes on the basis of the amount of slag which will be blasted by the explosive in each hole. The object of the blast is not to pulverize the slag but to break the slag mass into lumps which can be readily handled by slag-removal equipment.

In a rebuild of major proportions with extensive replacement of brickwork below charging floor elevation, fast slag removal is of primary importance to a rapid rebuild. Before the last tap of the furnace is made, the explosives are brought to a safe location near the job and prepared for use. As soon as liquid fuel lines are blanked, the pit is cleared of slag balls and other obstructions and the sides and top of the slag pocket seals are torn out to prevent excessive damage to steelwork at the pocket face. The cans of explosives are screwed together and attached to lengths of primacord shielded with asbestos tubing and placed in the pit in front of the holes in which they are to be inserted. Blasting caps attached to the firing lead wires are positioned at the side of the pocket with the extremities of the lead wires at a safe location. After all preparations are made, a horn is blown, charges are inserted in the holes using wooden poles, primacord from the individual charges are knotted to the cord from the blasting cap, the detonator is wired into the circuit and the "shot" is made. The second slag pocket is then prepared and blasted within 15 min of the first.

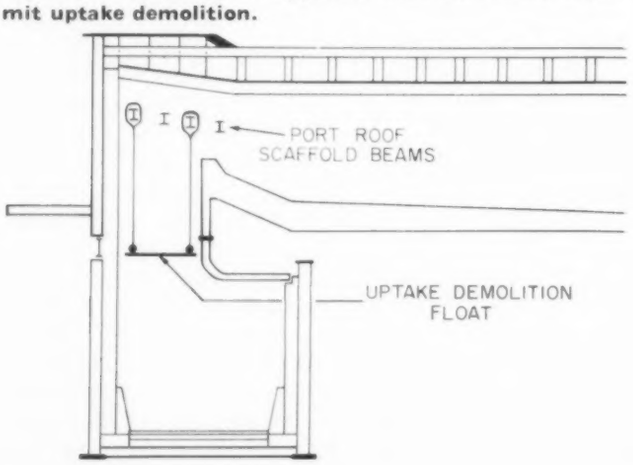
Immediately following slag blasting, the blasting mats are removed and mobile equipment is brought into the pit for slag removal. Track-mounted overloaders, a track-mounted ¾-cu yd backhoe with a "ripper tooth" attachment, as shown in Figure 3, and heavy duty motor trucks are used to remove the slag and haul it to a dumping location. Another tool found useful in removing slag and damaged brickwork in the

Figure 3 — The slag is removed from the slag pocket by mechanized equipment.

Figure 4 — The floor side wall and end wall are knocked in using a ram mounted on a full track vehicle.

Figure 5 — Instaliation of beam supports across the skewbacks requires a crane supported counterbalance.

Figure 6 — A scaffold is supported from the beams to permit uptake demolition.



slag pockets is a track-mounted front-end loader with a ram attached, as shown on Figure 4. In some cases, when slag in the pocket is very high or when furnace slag has leaked into the pocket during the campaign, a second blast must be made to facilitate removal of very large slag lumps.

During slag removal, it is often possible to accomplish considerable teardown of furnace ends. Co-ordination of forces and close supervision are required to promote safety when teardown is being done both above and below charging floor elevation.

In tearing down the furnace end, the first move is to knock in the floor side wall and the end wall with the track-mounted ram (Figure 4) so that the underside of the port roof is visible for inspection. Port roofs are generally replaced on major repairs, but in some cases, the outboard half of the port roof may be saved. If the entire port requires replacement it is either knocked down with the track-mounted ram or pulled down with a cable by the floor crane.

After the port roofs are down and co-ordinated with removal of blasted slag from the pocket, teardown of brickwork above charging floor elevation continues. The floor side wall and most of the end wall are knocked in by the ram. Because of inaccessibility, the pit side wall is torn down with hand tools. The charging machine peel is also quite effective in tearing down the end above charging floor elevation. As end teardown progresses, constant inspection must be made of uptake brick condition so that needed forces and equipment will be available to accomplish teardown without delay.

If the furnace condition is such that major work will be required below charging floor elevation, four heavy, wide flange beams, shown in Figure 5, are installed across the uptake under port skewback elevation. Installation of these beams is accomplished with a counterweighted balance beam and either a mobile crane, pit crane or floor crane. The beams are installed as soon as teardown has proceeded to the point at which installation becomes possible. The port roof scaffold beams serve two important purposes: movable teardown scaffolds hung on winches and used for uptake demolition are suspended from the beams; and the beams may be decked and used to support the port roof center so that the port roof may be replaced at any convenient time during the repair. Demolition scaffolding is shown in Figure 6.

Uptake demolition scaffolds are suspended from the port roof scaffold beams and lowered into the uptake as needed. Figure 7 shows an uptake demolition scaffold being prepared for use. Although considerable demolition of furnace and brickwork can be accomplished during slag removal, the removal of slag is of greatest importance to a fast rebuild and is not interrupted to accomplish other work. Unless some delay is encountered in slag removal, brickwork demolition does not normally progress into the uptakes until slag removal is complete. Brickwork teardown and slag removal are done in a co-ordinated manner with emphasis upon slag removal.

Once the slag is out, major emphasis is placed on the removal of damaged brickwork in the uptake. Cutting can be done from the uptake scaffold and from the furnace structural steel framing. During the time spent in tearing down the uptake, four large beams are

installed in the slag pocket by a mobile crane, as shown in Figure 8. The four slag pocket scaffold beams are used for tearing down bad brickwork in the suspended chill area and will also be used during rebricking. The slag pocket scaffold beams are sufficiently high to allow mobile equipment to enter the pocket to perform final cleaning without stopping work in the chill and uptake area.

At the completion of furnace end teardown, rebricking is started immediately using the scaffolds and hoists shown on Figure 9. The uptake demolition floats are removed from the furnace, the slag pocket scaffold beams and port roof scaffold beams are decked over, and jib booms with air hoists are mounted over each uptake opening for brick handling. Decking over of the beams at both elevations, in effect, breaks the furnace end into three separate work areas: slag pocket; uptake and end above floor and port roof. All can be rebricked simultaneously in the interest of time savings.

The uptake area is stocked with pallet-loads of brick lowered into the uptake by the hoists at charging floor level. Buck scaffolds are installed at 5-ft intervals from the slag pocket scaffold as brickwork progresses through the uptake. As soon as the middle arch has been keyed and leveled over, lock scaffolds on tapping bars are used to support bricklayers and stock. Lunch periods are used to remove the slag pocket scaffolding without interrupting brickwork in the pocket. At the time when uptake brickwork approaches charging floor level, the jibs used for stocking are removed and replaced by gravity roller lines. During rebricking of the uptake, all open areas above the charging floor are screened with $\frac{3}{4}$-in. opening expanded metal to prevent the possibility of bricks, scrap and debris falling on workmen in the uptakes.

Once the port roof scaffold beams have been installed and decked, replacement of the port roof may be made at any convenient time during end rebricking. Usually, the port roof centers are installed at a time when the demand for carpenter forces on the rebuild is small. The roof is rebricked after the main roof is completed or after that time when bricklayer forces are available. The installation of the port roof while other end rebuilding is in progress represents a time savings of from four to eight hr on the rebuild and also promotes better utilization of available forces. After the port roof centers are set, a stock scaffold, shown in Figure 10, is installed on the furnace front buckstays to receive roof brick in pallets from lift trucks operating on the charging floor. After completion of the port roof, bricklayers strip the centers and the port roof support decking and beams are removed during a lunch period. Here again, stress must be placed on co-ordination to insure the rebricking of the port roof and removal of the beams before uptake brickwork is hampered by the presence of the beams.

Simultaneous with uptake and port roof replacement, required repairs are also made in the slag pocket. Working under the decked slag pocket scaffold, slag pocket walls are trimmed down to good foundation and remaining slag, rubble and debris are removed to the elevation of concrete paving. In rebricking the pocket, salvaged silica brick are used to lay up a false wall which protects the pocket wall from damage by slag and blasting on succeeding rebuilds. Between the

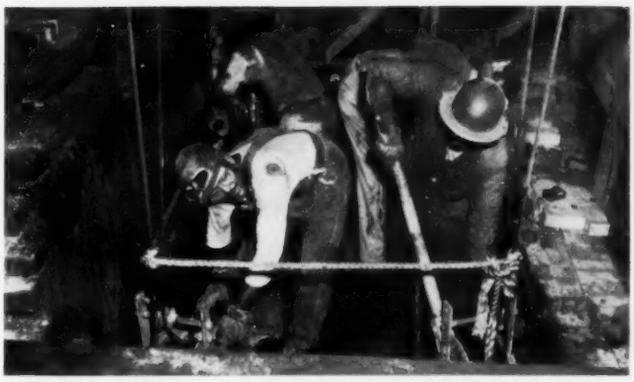


Figure 7 — The scaffold is lowered or raised by means of four winches.

Figure 8 — Beams are installed across the slag pocket to speed the teardown.

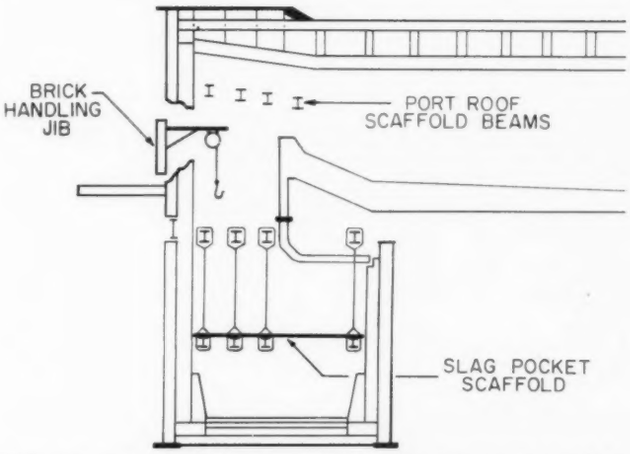


Figure 9 — A scaffold supported by the beams is used in rebricking of the slag pocket.

Figure 10 — Brick is stacked on a scaffold, placed against the front buckstays, to facilitate port roof installation.

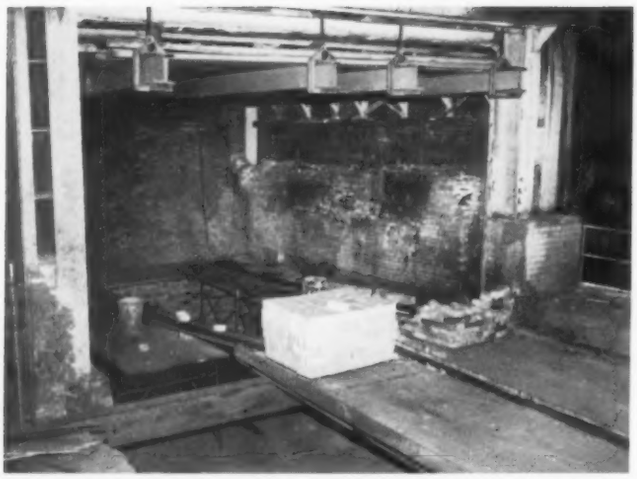


Figure 11 — Pallets of brick are brought to the slag pocket work level using special ramps.

pocket wall and the false wall, a 4-in. space is left and slag-wool mats are placed in the void to facilitate the next slag removal. If replacement of pocket walls is necessary, pocket walls and false walls are laid simultaneously to eliminate scaffolding a second time. Brick used in the pockets is brought from flat bed tractor-trailers in the pit by pneumatic-tired fork lift trucks. As the brickwork proceeds upward, a large beam is installed across the face of the pocket, ramps, shown in Figure 11, are placed on the beam from the pit and pallets of brick are delivered to the pocket by lift truck. After the pocket wall brickwork is completed, sand is spread to a depth of 2½ ft in the pockets, a loose course of salvaged silica paving is placed on the sand, and the pocket is ready for sealing.

Main roof and hearth—In spite of the fact that rebuild time is controlled by progress in the ends of the furnace, repairs and replacements in the main roof and hearth area must be completed at the same time as the ends. Close co-ordination of main roof and hearth work based on knowledge of time and manpower requirements elsewhere on the job can result in economies gained from optimum utilization of force during the rebuild. During an extensive rebuild of 4-day duration, delays of 24 hr in the main roof and hearth area may be absorbed without increasing rebuild time. During short rebuilds or in cases in which considerable replacement of furnace bottom materials is required, the main roof and hearth area can become most critical in timing.

Figure 12 — A permanent platform attached to the back wall buckstays is used during rebuilding of the furnace.

As soon as the fuel lines are blanked, the main roof is cooled and dropped. Watering the roof is started through wicket holes in the furnace doors and continued during the time the doors and frames are being stripped. The importance of divorcing the rebuild from operating equipment must be re-emphasized.

Stripping continues and doors, frames and damaged skewback channels are removed. The track-mounted ram is used to push in or knock in the roof when sufficiently cooled. The ram is also used to push front wall piers into the hearth. The back wall is cut down by hand and dropped to the hearth by laborers standing on the counterweighted, hinged repair platform, shown in Figure 12. The back-wall platform is permanently attached to the back buckstays. Debris from the roof, back wall and front wall is raked out of the hearth with a truck-mounted excavator and then pushed down the flush hole by a bulldozer. After the rubble has been raked out of the hearth, the front wall, back wall, bridge walls and monkeys are cut to suitable foundations with pneumatic cutting tools. If steel in the bottom has been reported or can be seen, slag guns, oxygen lance pipes and hydraulic jacks are used to remove the lumps. If preliminary investigation shows that steel in the hearth consists of small lumps only, excavation is delayed until later in the job after installation of the roof. Large lumps are removed before the roof is installed so that the overhead cranes may be used to assist in pulling. Front and rear skewback channels are realined or replaced at the same time that the front and back walls are being cut. When the door frames are replaced, rebricking of the front wall starts.

Due to the relative speed with which main roof and hearth components can be prepared for rebricking, the front wall, the back wall and the roof are usually the first bricklaying jobs that can be done on the rebuild and an earnest attempt is made to advance brickwork in these areas early in the rebuild so that bricklayer forces may be concentrated on the furnace ends when teardown of the ends is completed. If the front wall and back wall cutting is completed during the night, the front and back walls are replaced before setting the roof center. If the completion of front and back-wall cutting occurs on the day turn, carpenters are called from other plant work to set the center before replacement of the front and back walls.

The roof center used at Sparrows Point consists of a timber framework suspended on steel hanger rods at the rear and supported by posts at the front. A roof center for a silica roof is shown in Figure 13. The two-piece wooden ribs are set at 30-in. centers along the frame and lagging is nailed to the top chords of the ribs. The wooden center has been found very adaptable to changes of span, rib spacing, roof brick thickness and roof weight. After the center is installed, a stock scaffold similar to that used for port roof stock is installed at the front buckstays to receive pallets of roof brick from lift trucks operating on the charging floor. Gravity roller lines are used to transfer brick from the stock scaffold

to the center. If a sprung arch basic roof is to be installed, the center is reinforced by installation of additional posts, an increased number of ribs more closely spaced and heavier lagging. Rebricking of the main roof and removal of the center are completed by 12 to 16 hr before gas fire so that time remains to reshape the furnace bottom with rammed refractory materials. Stripping the center is accomplished by removing the frame supports, thus dropping the entire center to the hearth from which the lumber and ribs are loaded onto trailers and removed from the job.

After the center has been stripped, all debris is thoroughly cleaned from the hearth and a level is used to determine the thicknesses of the bottom material to be used in returning the hearth to desired contours. Magnesite is mixed on the charging floor, loaded into the furnace doors by end-dump boxes, shoveled to the required locations on the hearth and compacted with pneumatic tampers.

On normal rebuilds, completion of all required work in the main roof and hearth area is co-ordinated so that the furnace is able to be heated with gas as soon as hearth preparation is completed. Regenerator work and furnace end work being done below the elevation of slag pocket arches need not be completed until eight hr after gas firing has started. Before the gas can be lit, all scaffolds are stripped from the uptakes, a gas burner is installed in the center of the hearth, a final check is made of burner cooler setting, furnace dampers are closed and the furnace doors are replaced. Then the hearth burner and furnace burners are lit, the roof temperature, as recorded by thermocouples in the key of the main roof, is increased at the rate of 125 degrees per hr to 600 F, then at 150 degrees per hr to 1200 F, at which time the furnace is ready for reversing and the rebuild must be complete with all seals in place. When liquid fuel firing is started on the heatup, the furnace is placed in the hands of the operating department.

Regenerator rebuilding—Cleaning and repair work in the regenerator area, as a general rule, does not set the pace of the rebuild, but it must be completed by the time the oil firing starts. In order to co-ordinate a fast rebuild, with the pace set by the furnace ends, it is important that a thorough knowledge of the extent of work in the regenerator area be gained very early in the rebuild. Attention must be concentrated on the regenerator sections reported by the operators as "hot checkers" or "poor draft." Reports of checker maintenance and flue-blower crews indicate "slagged holes" and "slag in flues" and these conditions also must be corrected during the rebuild. If soot-blower operations have been unsatisfactory or questionable in any particular flue alley, an investigation must be made to determine required repairs.

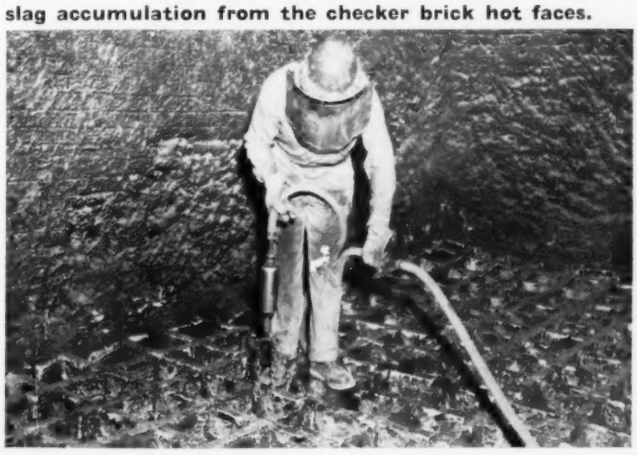
As soon as the fuel lines have been blanked and purged, first pass (hot pass) checker seals are opened and air-and-water sprays, shown in Figure 14, are laid on the top of the checkers to cool the brickwork. In the design and operation of checker sprays, it is of utmost importance that no water be sprayed on the hot regenerator roofs or considerable damage may occur. During these early hours of the rebuild, a thorough inspection of roofs, fantails and checker tops will show the chambers and areas which require most

Figure 13 — The roof center is held in place during the roof installation by a timber framework hung on steel hangers.

Figure 14 — Sprays are used to cool the checker brickwork.

Figure 15 — Flue debris is shoveled into buckets and hoisted out of the regenerators.

Figure 16 — An air-powered tube cleaner is used to remove slag accumulation from the checker brick hot faces.



attention. Forces become available for regenerator maintenance work 6 to 16 hr after the rebuild begins and priorities of work in the various regenerator sections must be determined by this time.

The first work accomplished in the regenerator area is the cleaning of the first pass flues. First preference in flue cleaning is given to those alleys in which there is slag or extremely high concentrations of flue dirt or the alleys beneath chambers requiring extensive replacements. Cleaning is done by shoveling the flue dirt from the alley into 20-in. diameter by 20-in. high buckets which have been placed on wheeled dollies, shown in Figure 15. The filled buckets are rolled under a manhole and hoisted to cellar level by an air hoist. At cellar level the buckets are dumped either into fork lift end-dump boxes or wheelbarrows or onto the ground at locations accessible to a pit bulldozer. Although this system of removal of dirt and debris from flues may seem rustic and inefficient, as yet no more economical, efficient or adaptable system has been successfully demonstrated to handle dirt, slag and brick rubble from the flues.

As soon as flues have been cleaned, checker cleaning or replacement may be started. An inspection of the chamber will indicate whether any checkers need be replaced due to insufficient thickness, faulty alinement of holes, or large numbers of slagged holes. The chamber is then "lined up" as to the number of courses to be removed and the area of the checkers requiring that depth of replacement. Using this line-up, laborers enter the chamber and make the prescribed cut, using caution to prevent brickbats from falling into the checker holes. After the chamber is cut, a reinspection is made to be sure that suitable foundation exists for new work. If the cut is deemed satisfactory, the remaining checkers are cleaned.

Cleaning of checkers is started by scraping the tops with a hotbar. Next, obstructed holes are opened by driving coupled short lengths of pipe through the obstruction either from the top or from the bottoms. An earnest attempt is made to open each hole and if it is found that many holes in one particular area of a chamber cannot be opened, serious consideration is given to removal of that area. After all holes have been opened, an air-powered rotating chain flail "eggbeater," shown in Figure 16, is lowered through the hole to remove slag encrustations from the checker hotfaces. After opening the holes and eggbeating, the rider arches are scraped clean, the chamber is reinspected to be certain that checker removal and cleaning are satisfactory, the flues are recleaned and the chamber is turned over to the bricklayers for checker replacement.

On some rebuilds, generally poor checker conditions warrant replacement of entire checker chambers. The removal and replacement of an entire checker chamber can become a factor in rebuild time due to the relatively long time and large force required to do the job. In instances in which entire chambers are to be removed, several lb of explosive are distributed in holes at different locations in the chamber and a "shot" is made as soon as possible after the seals are opened. The purpose of the blast is not to disturb the configuration of the chamber, but only to break the bond between bricks and slag masses in the chamber to promote removal with hand tools rather than cutting the chamber with pneumatic tools. After blasting, dirt and brick rubble are removed from both the top and bottom of the chamber in the interest of time saving.

Regenerator roofs and fantails are inspected as soon as the checker seals are opened to determine the extent of repair required. If roofs or fantails require patching only, the patches are made at any time forces are available from other work on the rebuild. The complete replacement of fantails presents no problem on normal rebuilds because the fantails are somewhat isolated from and protected from other furnace components. Regenerator roof replacement does not normally require special timing or co-ordination. In most cases in which regenerator roofs are to be replaced, the checkers under the faulty roof are covered with corrugated steel sheets to prevent rubble from filling checker holes, the roof is dropped and thrown out, checker cleaning and repairs are completed, a center is erected and the roof replaced. However, in some cases in which the roof and a large portion of the checkers in a chamber must be replaced during the course of a short rebuild, both jobs can be worked simultaneously by covering the checkers, dropping and throwing out the roof and installing the roof center on a bridge spanning the chamber thus allowing roof brick replacement and checker removal and replacement to be accomplished together.

In replacement of checkers, care is taken to keep holes vertical and in good alinement. Checkers are laid dry except for the top three courses, which are laid in air-setting mortar to prevent brick from being knocked over and into the holes when checkers are blown clean during the campaign.

During the latter phases of the rebuild, the second-pass checker seals are opened and compressed air is used to remove soot collars from the checker openings. Second-pass flues, backsewers and damper seats are also cleaned if the cleaning is deemed necessary. At the time of gas fire in the hearth, all work on the furnace is co-ordinated so that all seals will be completed in eight hr at "oil on" time.

OTHER REPAIRS ACCOMPLISHED

During the course of the rebuild, repairs other than removal and replacement of brickwork are made as required. Considerable concrete and structural repairs are made to the charging floor around the furnace. Damaged buckstays, binders or other structural components are repaired or replaced. Furnace dampers, damper seats and reversing mechanisms are inspected and repaired or replaced. Cooling water systems are repaired or cleaned as required. The soot-blower system is air tested if the blowers have not operated successfully and repairs are made. On normal rebuilds, the miscellaneous repairs do not lengthen rebuild time although planning and co-ordination is required to fit these projects in the rebuild schedule.

The alterations involved with conversion to basic brick construction and to oxygen-lance operation can also be scheduled into a major rebuild without severely lengthening rebuild time. However, conversions and major structural alterations are handled and planned as special jobs rather than normal rebuilds.

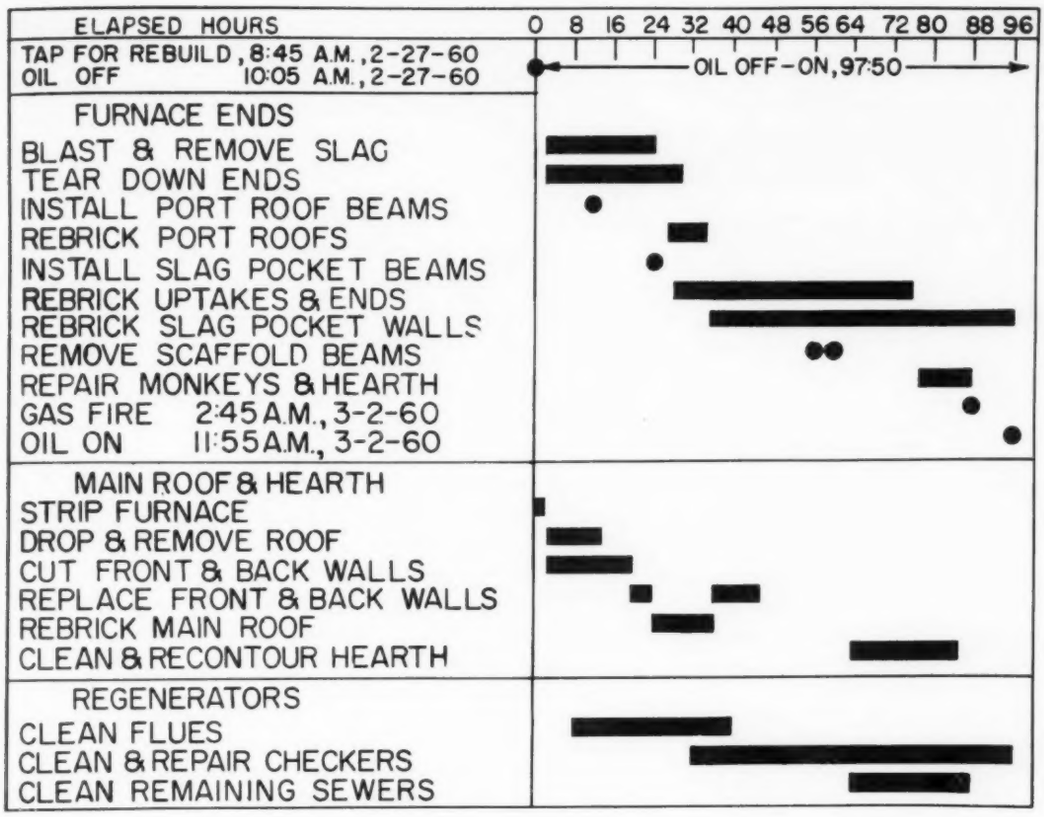

ELAPSED HOURS
0 8 16 24 32 40 48 56 64 72 80 88 96
TAP FOR REBUILD, 8:45 A.M., 2-27-60
OIL OFF 10:05 A.M., 2-27-60
OIL OFF-ON, 97:50
FURNACE ENDS
BLAST & REMOVE SLAG
TEAR DOWN ENDS
INSTALL PORT ROOF BEAMS
REBRICK PORT ROOFS
INSTALL SLAG POCKET BEAMS
REBRICK UPTAKES & ENDS
REBRICK SLAG POCKET WALLS
REMOVE SCAFFOLD BEAMS
REPAIR MONKEYS & HEARTH
GAS FIRE 2:45 A.M., 3-2-60
OIL ON 11:55 A.M., 3-2-60
MAIN ROOF & HEARTH
STRIP FURNACE
DROP & REMOVE ROOF
CUT FRONT & BACK WALLS
REPLACE FRONT & BACK WALLS
REBRICK MAIN ROOF
CLEAN & RECONTOUR HEARTH
REGENERATORS
CLEAN FLUES
CLEAN & REPAIR CHECKERS
CLEAN REMAINING SEWERS

Figure 17 — The actual schedule of a furnace rebuild during which 316,176 9-in. equivalent brick were laid.

SAFETY

Of all the steel plant maintenance groups, the forces engaged in open hearth rebuilds are subjected to the most frequent and most severe hazards from operating conditions in the repair area. The charging, service and tapping of furnaces adjacent to the rebuild necessitates the use of extreme care and caution in the planning and in the performance of rebuild work. Close co-ordination of operating and repair forces to promote the safety of both is of prime importance. In addition to the hazards of the open hearth operation, additional hazards are presented by the concentrations of repair crafts at all parts and elevations on the furnace being rebuilt. Each workman and supervisor must be alert and on guard to be sure that each of the many work areas is in safe condition at all times. Costly accidents on open hearth rebuilds can be prevented by thorough planning, close co-ordination and constant watchfulness of all personnel in the rebuild area.

REBUILDING OF NO. 92 FURNACE

The general repair of No. 92 open hearth furnace at Sparrows Point No. 4 open hearth shop was started on February 27, 1960. The furnace had tapped 238 heats since the previous rebuild. During the course of the rebuild, 316,176 9-in. equivalent brick were used in the 97 hr and 50 min between oil off and oil on. The scope of the rebuild of the 375-ton furnace included the following:

1. Replacement of 13½-in. silica main and port roofs.
2. Replacement of the front and back walls.
3. Repiped taphole, used 25 tons of rammed bottom material to recontour hearth.
4. Replacement of both burner coolers and eight skewback channels.
5. Replacement of both ends above floor and both uptakes complete in suspended basic brick.
6. Removal of 325 cu yd of slag from pockets.
7. Replacement of large quantities of slag pocket side wall brickwork.
8. Replacement of all slag pocket false walls and seals.
9. Replacement of fantail nose walls and regenerator division walls to checker level.
10. Replacement of an average of ten courses of all first-pass checkers.
11. Cleaning of all flues, first-pass checkers and damper seats.

A line schedule of the rebuild of No. 92 furnace is shown in Figure 17. The furnace ends determined the time of the rebuild. No furnace work was done on the main roof and hearth area for almost 24 hr. A major charging rail and floor repair was accomplished during this 24-hr period.

This article has been presented on the open hearth furnace rebuilding procedures as used at Sparrows Point with the thought it might contribute to such work at other plants. However, a successful open hearth furnace rebuilding program must depend upon complete understanding and cooperation between the maintenance and operating departments. The completion of a particular open hearth furnace can give a sense of accomplishment to all concerned only if the work is completed without a lost time accident.

Discussion

PRESENTED BY

E. G. KONDAS, Assistant Superintendent, Cleveland District, Republic Steel Corp., Cleveland, Ohio

JOHN YOXALL, Masonry Superintendent, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Mich.

CARL F. BESSENT, Supervisor of Maintenance, Mechanical Engineering Dept., Bethlehem Steel Co., Sparrows Point, Md.

H. R. KNUST, Assistant General Manager, Bethlehem Steel Co., Sparrows Point, Md.

W. J. SCHARFENAKER, Chief Ceramic Engineer, National Steel Corp., Ecorse, Mich.

E. G. Kondas: The author has logically reduced the approach to this whole problem of furnace rebuilding to three main areas:

1. The importance of prescheduling and preplanning of open hearth rebuilds.
2. The equipment and procedures used in dismantling open hearth furnaces.
3. The equipment and procedures used in rebuilding open hearth furnaces.

Prescheduling and preplanning are areas that are becoming more and more important as each day goes by. There are furnaces that will give 400 to 500 heats or more on a roof, or furnaces that will produce 60 to 100 tons per hr. It is evident that such furnaces must be rebuilt faster and better than before. Furnaces of this nature automatically become costlier units per hr when they are down and not producing. Therefore, in order to rebuild furnaces faster and better, it means that operators and craft people must get together and through a mutual exchange of ideas come up with a workable plan to build a solid performing furnace in a minimum amount of time. The author in his paper explained the preplanning and prescheduling procedures used by his organization. That employed at Republic is essentially the same. Rebuild co-ordinators follow rebuilds around the clock. Their first job consists of contacting operators and craft people to get ideas as to the extent of the work necessary when a furnace goes down. After this data is collected a rebuild schedule for each furnace is constructed. This schedule is checked by the people involved for any change. When the furnace goes down this schedule is posted at the furnace and becomes the recipe for any future action on the furnace. The co-ordinators control the working of the schedule. Each morning a short rebuild meeting is held at which time a co-ordinator will discuss the progress of the rebuild indicating which craft is on or off schedule and what can be done to get crafts back on schedule. Preplanning and prescheduling of rebuilds is an important phase to a good rebuilding program.

Modern furnaces are 90 to 100 ft long, 20 to 22 ft wide with checker volumes around 15,000 cu ft, slag pocket volumes around 12,000 cu ft, hearth areas of 1200 to 1500 sq ft and a structure that has approximately 500,000 brick when it is fully constructed. The thought of dismantling or rebuilding such a unit quickly and efficiently by crude hand methods is absurd. Good procedures and good equipment must be used to do a fast job of dismantling. In the future even better procedures and better equipment will be necessary to have a sound rebuilding program.

The author mentioned many interesting and efficient methods and equipment used in dismantling furnaces in his shop. Our shop has been experimenting recently with an interesting piece of equipment. It is a portable flue dust cleaning machine that has been in service almost nine months. During this period of time it appears to be at least one answer to the problem of removing flue dust from an open hearth furnace. Using the old method of hand labor and buckets the flue dust from one side of a furnace could be removed in 35 hr with nine men. With this machine the same amount of dust can be removed in 28 hr with five men. More and better mechanized equipment is an absolute must for a successful rebuilding program.

In speaking of the equipment and procedures used in rebuilding furnaces today, attention becomes focused on the handling problem. In order to overcome this problem, better procedures and methods and better equipment to transport and deliver this material not only to the furnace but to the actual job site must be found.

John Yoxall: Great Lakes Steel Corp. operates on the same basis as Sparrows Point and like all other mills is striving every day for better and faster ways to rebuild the open hearth.

In the past few years the service and maintenance people have become, instead of a necessary evil to the open hearth people, an important factor in the over-all steel production picture.

The best attempt so far on our 500-ton all basic furnace rebuild is 97 hr.

The teardown scaffold used in the uptake is a good approach. The ram used for dismantling the roof and side walls is also good.

The timing on each phase of the furnace in order to complete all areas at the same time is to be commended and is absolutely necessary in order to complete a rebuild in 97½ hr.

What the future holds for the open hearth furnaces since the advent of the basic oxygen furnaces is not known, but in the competitive market today service and maintenance departments must look for new ways to improve furnace availability. The production department also can help.

All furnaces are inspected twice each week by members of production and masonry supervision and plans are laid accordingly, not only for the rebuilds but also for hot patching, by our planning engineer who is also a member of the masonry department.

In the not too distant future it is possible that the planning will be such that a furnace can be taken out of production on Sunday midnight and can be finished before Friday so that the service and maintenance people can enjoy their weekends. It takes a lot of work by a lot of people operating as a team to give maximum furnace availability at a reasonable cost.

Are all the departments working on the furnaces

under an expeditor and is he from the masonry department?

Carl F. Bessent: The rebuild crafts are guided by a co-ordinator. The co-ordinator is not from the brick department.

John Yoxall: How long does it take to install a basic roof?

Carl F. Bessent: Basic roofs have been installed in a 24-hr period, but in most rebuilds, time consumed in installation of the main roof is of little importance to the total rebuild time.

John Yoxall: Have you experimented with your roof plates and if so, what do you think is the best and most economical construction—9 in., 12 in. or 18 in. between plates?

Carl F. Bessent: To date there has been no experimentation with roof plate spacing at Sparrows Point. A 9-in. spacing of plates has been used on all basic roof installations.

H. R. Knust: The problem of open hearth rebuilding is a very important one today, particularly with the advent of oxygen. The rebuilding of open hearth furnaces is one of the largest items of maintenance cost, as well as furnace downtime affecting over-all cost. Therefore, jobs such as this, which are admittedly repetitive and routine, cannot be permitted to become stereotyped.

W. J. Scharfenaker: Please describe briefly the timing, the crafts involved and the methods and tools used in demolishing a worn-out basic roof.

Carl F. Bessent: Basically, the same forces are used to demolish basic as silica roofs. With the basic arch, burners must sever the restraining tie angles before the brick will fall. There has been little difficulty with downing or handling the materials from the basic roof.

W. J. Scharfenaker: What type of crafts are involved in the men who are cutting loose all the fouled up and pulled down steelwork?

Carl F. Bessent: Erectors do the dismantling of the support beams and rods in an orderly fashion after the brickwork and tie plates have been knocked in by the labor group. Considerable salvage of rods and beams on the job can be realized through an orderly dismantling procedure.

W. J. Scharfenaker: You described watering down silica roofs, do you do the same on basic?

Carl F. Bessent: The basic roof is also watered down.

W. J. Scharfenaker: Is cooling of main roof an important time factor?

Carl F. Bessent: The removal and replacement of the main roof is not the primary time-determinant on open hearth rebuilds. Forces applied to the dismantling of the main roof determine the speed with which the hardware is removed. Water is used to cool working areas as required during dismantling. ▲

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Safety for Steel Plant Electrical Men

by J. F. TRENNER, Assistant Superintendent, Electrical Dept.
Bethlehem Steel Co., Sparrows Point, Md.

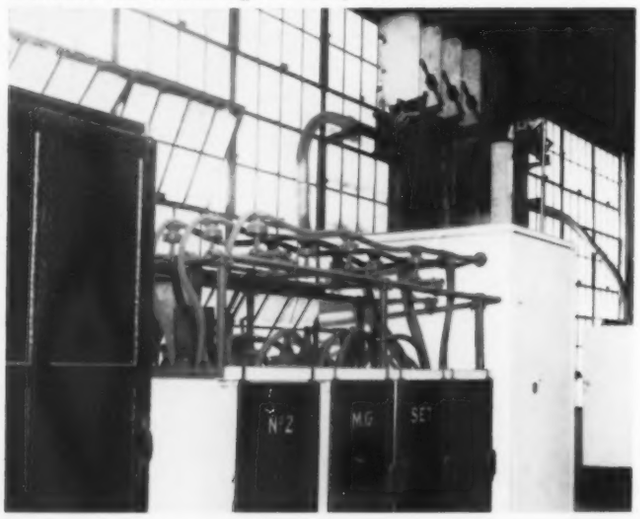
. . . availability of safety equipment and the distribution of printed material must be supplemented by repeated training covering equipment theory, safe job procedures and modern first aid methods, if a safety program is to provide continual protection for the employee. . . .

THE Bible records the use of iron in prehistoric times in Genesis IV, 22, and historians tell us that iron was known in Egypt about 7000 or 6000 B.C. The use of steel is recorded in writings by Aristotle in 322 B.C. which describe the process by which the people of India produced the metal for the "Swords of Damascus." During the span of over 7300 years iron and steel were worked by hand, gas, air, water, oil and steam power.

In 1842 the first practical application of electricity was made in an electroplating plant in England. From that time the application of electricity in the steel industry has increased phenomenally. Higher transmission voltages, atomic power generation, semiconductors, data processing and computor applications are modern advances.

The past century has seen the introduction of electricity to the industry: its impact in the last 25 years is nothing short of astounding. Certainly the ability and skill of the average electrical workman has not kept pace with the electrical applications, especially during the past two decades.

Figure 1 — Open disconnect switches and bus work were standard items during the early 1920's.



Even more recently than the advent of electricity in steelmaking (in the last three quarters of a century), the industry has formally recognized the need for safety for the employee. In 1892 the Joliet works of the Illinois Steel Co. formed its safety dept.; which has been referred to as "the birthplace of the American industrial accident prevention movement." In 1906, United States Steel Corp. set up a safety committee to inspect its works and suggest means of accident prevention. The AISE was originally founded in 1907 and at Milwaukee, Wis., in 1912, a small group of men interested in safety work met under its auspices. This group was formed, of 14 members who were representatives of industry, government, insurance companies and other interests, to exchange ideas. In its first year the committee expanded to 971 members and in 1913 its name was changed to the National Safety Council.

The electrical industry has made major contributions to the safety of the electrical man in the steel industry, see Figure 1. Open high-tension bus structures with their oil circuit breakers and open disconnects, which were the vogue 40 years ago, have given way (Figure 2) to enclosed bus structures with high-speed air circuit breakers of the draw-out type. Not only have many safety features been built into equipment, but hazards for the plant electrical personnel have been reduced, see Figure 3. Low-voltage breakers of the open type have given way to totally enclosed models of improved design, see Figure 4.

Many organizations, both governmental and industrial, have developed codes to help industry provide adequate protection in new equipment installations and the policing of older equipment. To mention a few: the National Electrical Code, the National Electrical Safety Code, crane codes, elevator codes, ladder and scaffold codes and codes for calculating injury disability statistics.

The attitude of management has changed. The Bethlehem goal is "Production With Safety." Production without electrical energy properly applied and controlled is impossible. This means that a safety program that will cover all phases of electrical maintenance and operation must be developed and implemented for electrical employees. Once this program has been decided upon in a plant, it must be carried to completion with adequate communication of the written and spoken word, for without proper communication a safety program cannot exist.

Safety principles are set up by the vice president's office and transmitted through the plant manager's

monthly safety meetings and daily operational meeting. These thoughts are passed on to department superintendents who hold meetings with their general foremen to discuss and broaden, as well as to assist them to apply the basic principles to their particular departments. In our case the electrical phase is stressed.

The general electrical foreman transmits this safety program to his subforemen and foremen, who hold meetings with the hourly employees. It is felt that each employee should be exposed to one general group-type safety meeting per month. The most important part of the program is that of stand-up safety meetings. This places on the foreman, who is in direct contact with the hourly employee, the responsibility of getting the safety message across in language and terms that the employee can understand. This line of communication is most important. Instructions alone are highly beneficial, but an attempt is made to augment this verbal transmission with a number of written and visual aids. It would be well to review these briefly, because they play an important part in the over-all program.

The electrical departmental safety code—This is a pocket size book, distributed to all employees to whom the rules apply. This code contains chapters governing general safety rules as well as specific rules for various jobs performed by the electrical men, such as jobs by the powerhouse and sub-station men, crane repairmen, electrical repairmen, etc. Any rule in these codes makes an excellent subject for a stand-up safety meeting or discussion. They are constant reminders for all jobs and circumstances.

The Job Safety Analysis Book—These JSA's are studies of the safe manner in which a job is to be performed. They indicate the various steps of the job to be done, the hazards that may be encountered and precautions necessary to overcome these hazards. JSA's are prepared by the supervisor in conjunction with the employees directly engaged in performing the particular tasks. When complete they serve as a procedure for ready reference and discussion so that proper protective equipment will be made available and job knowledge can be applied by electrical employees. At present, there are 1300 JSA's in use in the Bethlehem Sparrows Point electrical dept; and an average of 200 new ones are being written every year. They are also training guides for the new employee.

Figure 2 — Modern high-speed circuit breakers have reduced electrical hazards.

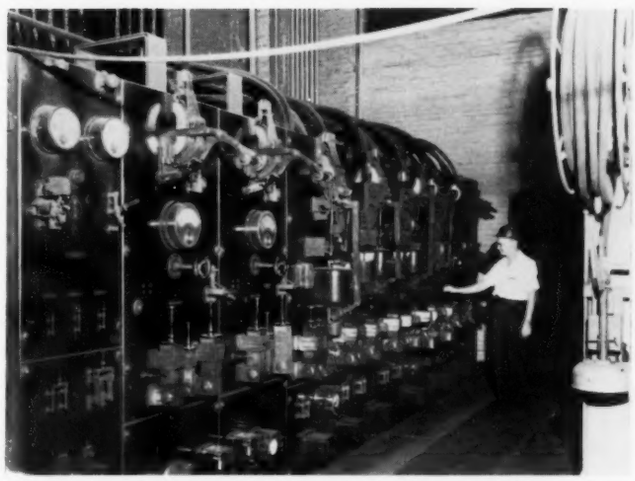


Figure 3 — This d-c panel was installed over 40 years ago and is equipped with a positive line switch only on the negative.

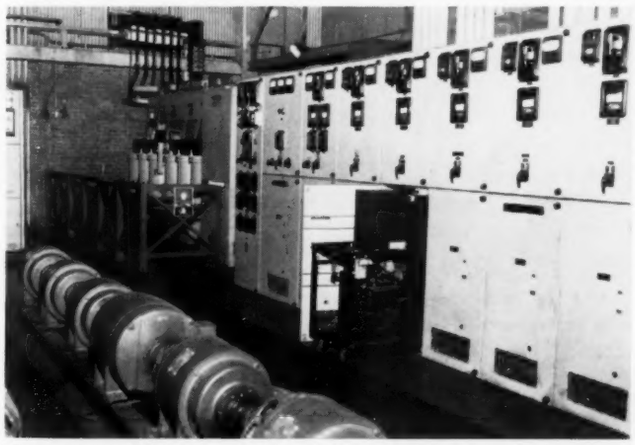


Figure 4 — Modern enclosed distribution panels have no exposed live parts.

There are various other pieces of printed material that play a big part. The monthly Supervisory Safety Contact Topics Book is pocket size to facilitate the foreman's recording of contacts. The monthly Safety Bulletin is a printed folder which is distributed from the home office to all supervisors and discusses current safety problems. The central safety dept. "Attention All Foremen" sheets are recaps of previous serious or disabling injuries and serve as reminders of pitfalls that others have experienced. Descriptions of accidents in other plants, and plants of the Seven Steel Company Safety Exchange are distributed which point out hazards of a type in which one can become involved. All of the aforementioned printed material is available "fresh" monthly for use by the foreman for his stand-up safety meeting, which is one of the most important parts of our safety program. It is a fact that the first-line supervisor is in most cases well regarded by his men. Who is better able to contact these employees and hold discussions on safety topics than the representative of management in closest contact with them? Each supervisor is expected to hold a minimum of four stand-up safety meetings with his men every month. The most difficult task in keeping records of these meetings is that of getting the supervisor to record his contacts on the forms provided.

Training is another important part of the safety program: a "how to supervise course" for our first-

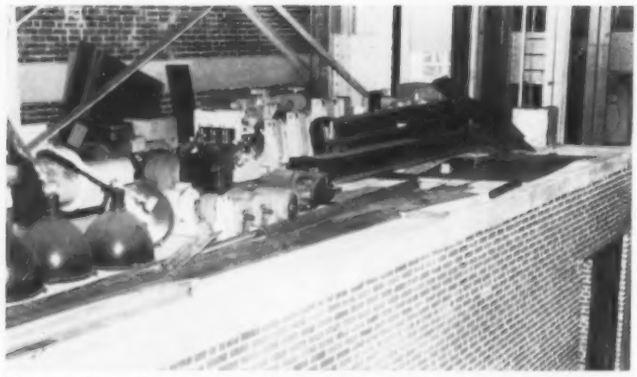


Figure 5 — Haphazard storage and lack of a guard rail was noted in a storage area on one of the inspections. Subsequent correction was made.

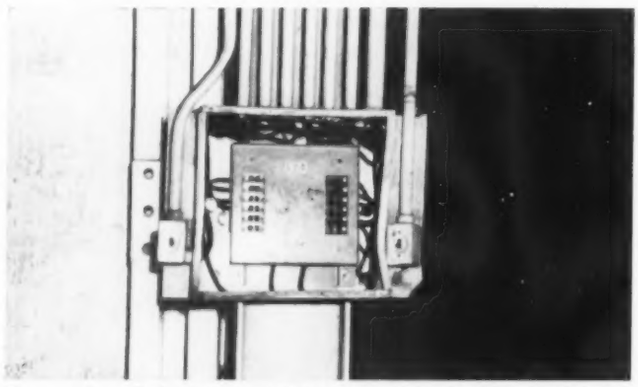


Figure 6 — A lighting distribution box had been hit by coke boxes and lift trucks.

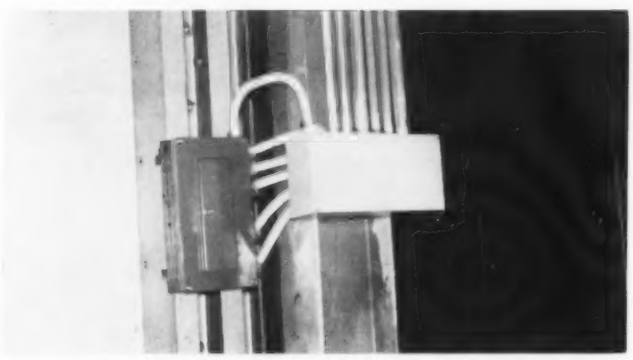


Figure 7 — Corrective action was taken to remove the hazard shown in Figure 6.

line supervisors gives these management people a background in organizing and planning work, induction of new employees, training techniques, discipline, cooperation and leadership. A large part of this course concerns the carrying out of a good safety program. An electrical helper's training course exposes the young employees, many of whom are hired with no previous electrical or work experience, particularly in steel plants, to basic knowledge that it is felt the future repairmen and motor inspectors should have. Subjects such a basic theory, methods of testing, a-c or d-c motor theory, blueprint reading, batteries and an introduction to technical developments are covered; and the safety aspects, as they pertain to the steel plant electrician are emphasized. A first-aid course in which selected electrical dept. employees are trained each year to qualify for the American Red Cross and Bureau of Mines certificates; a burning school for instruction on safe techniques and procedures (with an attendant reduction in repairs to burning equipment which is now more properly and more carefully handled by school graduates); and our gas school for those employees who will be subjected to work in gaseous areas are all provided to indoctrinate the employees in steel plant safe working practices.

Accident reports and cause coding are aids in the analysis of safety program results. Data on types of accidents and injuries can point up weaknesses in the program. Injury records also note the supervisor for whom the employee works. This also can point up a weak link in the training of employees, or the effectiveness of a particular stand-up safety program.

With regard to the personal protective equipment program, the employees wear hard hats, eye protection, safety shoes, rubber gloves, linemen's belts, gas masks, leather gloves, face shields, etc., as necessary for the safe performance of any job. A new employee is issued eye protection and a hard hat when he is hired. Safety shoes are made available to an individual through payroll deduction if the employee so desires. When a new man has the proper personal protective equipment, he is given a safety indoctrination lecture and then assigned to a foreman and an older hourly employee for further safety instruction.

Housekeeping in itself is an excellent indicator of the level of a safety program. An employee who is allowed to do a slovenly housekeeping job will do his work in a sloppy fashion. A man who fails to clean up his working area very likely will fail to follow a flag and tag rule properly. Bi-weekly, unannounced housekeeping inspections are held in the dept. with a team composed of the dept. safety supervisor, superintendent or assistant and two department foremen. Faulty conditions are brought to the attention of the proper supervisor. He must initiate corrective action within one week and make reports subsequently to the superintendent as steps are taken toward completion. Some examples of deviations and results are shown in Figures 5, 6 and 7.

Certainly in an electrical age with high production, quality control and cost control becoming more important daily in a highly competitive industry, management is aware that an employee saved from injury is a saving of cost. This cost, both direct and indirect, is broken down as follows:

1. Disruption of production.
2. Damage to equipment (repair or replace).
3. Medical treatment.
4. Compensation cost.
5. Loss of time due to inexperience or replacement.
6. Training of a replacement.
7. Time lost by supervision in performance of tasks involved in above.

This article has outlined the procedure followed to provide a safe atmosphere in which electrical employees can work. It is well at this time to point out that this is all aimed at the individual workman. An attempt is made to instill in the electrical man the desire to do his diversified tasks in the safest manner. All of the spoken word, printed information, posters, movies, slogans, signs and protective equipment will be of no avail unless the individual can be interested in his self-preservation. Employees are screened when they are hired in an attempt to get those with certain minimum

qualifications. From that time until the day they retire, everything is done including administering disciplinary action, to enforce and to make more effective the safety program and rules. It is realized that these men face many different jobs and experiences in their work day. To give them maximum protection, all safety rules and procedures must be followed implicitly.

1. Electrical industry contributions of safety engineering equipment.
2. Governmental and industrial codes.
3. Management attitudes.
4. In the plant:
   (a) Safety codes.
   (b) JSA's.
   (c) Stand-up meetings.
   (d) Training.
   (e) Personal protective equipment.
   (f) Housekeeping.

As a final thought, remember the basic slogan "Production With Safety." Electricity in the steel industry today is the most important tool of production, and without an accompanying safety program to protect the electrical employee, there will be no production.

Discussion

PRESENTED BY

H. C. MULLINGS, Assistant Superintendent, Maintenance Dept., Electrical Div., Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

J. G. MITCHELL, Superintendent, Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

J. F. TRENNER, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

H. C. Mullings: In general the safety activities and programs in the larger plants of the steel industry are patterned very much as outlined by the author. No doubt, this is the result of the cooperation and exchange of information among the safety people throughout the steel industry.

At Jones & Laughlin Steel Corp. the safety program includes two items, not mentioned by the author, which it is felt are important. In addition to a group safety meeting, each foreman makes one personal safety contact per week with each of his employees, and each foreman is required to make at least one safety observation of each employee under his supervision each month. The employee is closely watched during this observation for infraction of safety rules and procedures. Any infractions are immediately called to the workman's attention.

These contacts and observations give the foreman the opportunity to discuss safety with his men on an individual basis. This approach also gives each employee an opportunity to express his own ideas and views personally which he might not do at group meetings.

It is felt that this personal touch leads to better understanding and cooperation between the foreman and his men. The observation also is a check on how the employee has understood and follows safety instructions.

J. G. Mitchell: If the possibility for an accident exists in a certain operation and the operation is repeated often enough, then eventually the accident will occur.

When one considers the hazard potential of moving machinery and the live electrical equipment which electrical personnel must work with, it is certain that sloppy habits or mistakes, in obtaining clearances or locking out of equipment, will result in very serious accidents.

Before working on a machine, each man must be sure that effective clearance has been made and will not be released until the job is completed. On a single-motor drive this is a simple operation, for the man simply locks out the disconnect switch with his own padlock. However, on large production units employing many drives, the problem of obtaining safe working conditions is not so easily obtainable. On variable voltage control drives the armature loop circuit must be opened. The man must obtain a number of clearances for himself or rely on a second party to obtain these clearances for him. Where several trades are employed on a breakdown job and a number of men in each trade, the problem of providing that each man can be sure of his own safety, with respect to drive clearances, can become quite complicated. Many procedures have been developed where the man is obtaining a lockout through second and third parties.

Would the author care to comment on what he considers to be good procedure? I have in mind a breakdown job in the area of feed rolls on a modern slabbing mill where clearances on a large number of drives must be obtained for a large number of personnel.

J. F. Trenner: To go into detail on the tagging procedures can take a considerable amount of time, because there are so many different methods used, even within the plants of our own corporation. The Bethlehem plant uses locks, Lackawanna uses a combination of locks and flags, Johnstown uses the flag and tag while at Sparrows Point only the tags are used.

Each electrician is issued a high-visibility yellow plastic tag with the words, "do not close this switch" printed on one side, and his name and check number printed on the other. All mechanical dept. employees are also issued individual tags.

With regard to maintenance work on the feed rolls on a slabber, if an individual millwright and electrician are involved in this job, the electrician and millwright would go the motor room. The motor and control switches would be opened and they would both place their tags on the power switch. When more than one craft is involved in a large job, the leader of the group, which might include erectors, welders, electricians, millwrights, etc., is allowed to place his tag on the switch to protect his people. This does not preclude any individual from also placing his personal tag on the switch. This occasions a number of tags in some cases, but it is felt that the individual has the right to tag the switch in his own name even though the leader has tagged for it for the group. When the job has been completed, each person who has placed a tag on the switch is responsible for removing it. ▲

PROGRAM

Association of Iron and Steel Engineers

1961 Annual Convention

PENN-SHERATON HOTEL PITTSBURGH, PA.

SEPTEMBER 25, 26, 27, 28

MONDAY, SEPTEMBER 25

9:00 am—REGISTRATION—
Fort Duquesne Room

9:15 am—BUSINESS MEETING—
Urban Room

Conducted by President C. E. Pritchard

9:30 am—ELECTRICAL SESSION—
Urban Room

Chairmen: John P. Kostelac, Division Superintendent, Maintenance, Midland Plant, Crucible Steel Co. of America, Midland, Pa.

James A. B. Pinney, Assistant Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

"Recent Developments and Operating Experience in Control of Gage and Set Up of Strip Mills," by R. E. Marrs, Consulting Application Engineer, Metal Rolling Application Engineering, General Electric Co., Schenectady, N. Y.

"On-Line Computer Control for a Reversing Plate Mill," by A. W. Smith and L. P. Gripp, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Controls and Instrumentation for a New Sintering Plant," by W. J. Tunny, Superintendent, Electrical Maintenance, The Youngstown Sheet and Tube Co., East Chicago, Ind.

9:30 am—JOINT IHEA AND AISE SESSION ON CONTINUOUS FURNACE PROCESSING—
Monongahela Room

Chairmen: Hugh J. Pugsley, Senior Vice President, Swindell-Dressler Corp., Pittsburgh, Pa.

C. H. Vaughan, Assistant Vice President, The Electric Furnace Co., Salem, Ohio

"Continuous Strip Annealing," by W. P. Gill, Marketing Specialist, Industrial Heating Dept., General Electric Co., Shelbyville, Ind.

"Continuous Heat Treatment of Steel Plate," by N. K. Willis, Director of Engineering, Drever Co., Bethayres, Pa.

"Continuous Strip Galvanizing Developments," by Carroll Cone, Vice President—Engineering, Surface Combustion Div., Midland-Ross Corp., Toledo, Ohio

2:00 pm—OPERATING PRACTICE SESSION—
Urban Room

Chairmen: W. A. Black, Assistant Director of Research, Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

A. B. Glossbrenner, General Foreman, The Timken Roller Bearing Co., Canton, Ohio

"Continuous Galvanizing Practices and Trends," by Dean W. Ferguson, General Foreman, Galvanizing, Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Recent Developments in Strip Thickness Control," by I. G. Orellana, Head, Measurement & Control, Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

"Strip Processing," by Donald A. McArthur, Vice President—Engineering, The Wean Engineering Co., Inc., Warren, Ohio

2:00 pm—LUBRICATION SESSION—
Monongahela Room

Chairmen: A. E. Cichelli, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

C. E. S. Eddie, Plant Lubrication Engineer, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Mich.

"Crane Rail Lubrication," by Elmer E. Fleck, President, and Hugh L. Davis, Sales Engineer, Research Appliance Co., Allison Park, Pa.

"Effect of Fire-Resistant Fluids on Design and Operation of Hydraulic Systems," by William M. Schrey, Field Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

"The Selection and Evaluation of Rolling Oils," by R. W. Kenyon, General Sales Manager, Kerns United Corp., Chicago, Ill.

TUESDAY, SEPTEMBER 26

9:00 am—ELECTRICAL SESSION—
Urban Room

Chairmen: Elmer E. Barthel, Assistant Superintendent—Maintenance, Pittsburgh Steel Co., Monessen, Pa.

Clayton L. Squier, Assistant Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.

"Electrical Protection on High Capacity Systems," by Paul S. Potter, Electrical Engineer, Bussmann Manufacturing Div., McGraw-Edison Co., St. Louis, Mo.

"Application of Circuit Breakers with Symmetrical Ratings in Steel Mills," by Philip L. Camp, Manager, Low Voltage Engineering, I-T-E Circuit Breaker Co., Philadelphia, Pa.

"Electrical Lockout Procedures," by J. R. Lamberton, Electrical Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

9:00 am—COMBUSTION SESSION— Monongahela Room

Chairmen: C. W. Dunn, Superintendent Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

F. C. McGough, Superintendent, Fuel and Power, The Youngstown Sheet and Tube Co., East Chicago, Ind.

"Gas Analysis Applied to Blast Furnaces," by J. F. Triolo, Application Engineer, Iron & Steel Industry Div., Bailey Meter Co., Bala-Cynwyd, Pa.

"Computers in Fuel and Utilities Dispatching," by Lee I. Dickinson, Fuel Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

"Modern Blast Furnace Blowing and Gas Recovery Systems," by C. W. Dunn, Superintendent Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Obtaining 1800-F Blast from Existing Stoves," by Stephen Vajda, Project Development Engineer, Jones & Laughlin Steel Corp. Pittsburgh, Pa.

2:00 pm—BLAST FURNACE SESSION— Urban Room

Chairmen: C. A. Roberts, Jr., Chief Engineer, Phoenix Steel Corp., Phoenixville, Pa.

Stephen Vajda, Process Development Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"The Injection of Auxiliary Fuel into the Blast Furnace " by Dr. Julien Raick, Consulting Engineer, Brussels, Belgium

"Natural Gas Injection at Great Lakes Steel Blast Furnaces," by William H. Collison, Plant Superintendent, Blast Furnaces and Coke Works, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Mich.

"Sintering Fans—Selection and Design Considerations," by Gerald J. Durning, Chief Engineer, The Green Fuel Economizer Co., Inc., Beacon, N. Y.

2:00 pm—ROLLING MILLS SESSION— Monongahela Room

Chairmen: F. G. Kredel, Chairman Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio

R. P. Schuler, Superintendent, North Mills, Inland Steel Co., East Chicago, Ind.

"Technological Exploitation of the Stretch-Reducing Process," by Dieter Hancke, Vice President—Sales, and Robert Hartenstein, Vice President—Engineering, Mannesmann-Meer, Inc., Youngstown, Ohio

"Design and Performance of Recent Developments in Bar Mill Cooling Beds," by Wm. K. Stamets, Jr., President & General Manager, Northeast Ohio Machine Builders, Inc., Columbiana, Ohio, and J. Ralph Dye, Works Manager, Milton Steel Div., Merritt-Chapman & Scott Corp., Milton, Pa.

"Pass Reduction Schedule for Optimum Production from Hot Strip Mill," by Dr. Betzalel Avitzur, Research Engineer, Applied Science Dept., Scientific Laboratory, Ford Motor Co., Dearborn, Mich.

WEDNESDAY, SEPTEMBER 27

9:00 am—ELECTRICAL SESSION— Urban Room

Chairmen: H. W. Dorset, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

John A. Drgon, Division Superintendent—Maintenance and Utilities, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

"Motor Heating Effects of Reactor Type Control Systems for A-C Cranes," by J. A. Halvorson, Electrical Engineer, Bridge & Crane Control Section, Cutler-Hammer, Inc., Milwaukee, Wis.

"Something Different in Reactor Crane Control," by C. A. Schurr, Supervisor of Systems Development Section, EC&M Div., Square D Co., Cleveland, Ohio

"The Crane of the Future," by F. M. Blum, General Sales Manager, Industrial Div., Harnischfeger Corp., Milwaukee, Wis.

"The A-C Mill Motor—A New AISE Standard," by Malcolm B. Antrim, Chairman, AISE Mill Motor Committee, and Manager, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

9:00 am—COMBUSTION SESSION— Monongahela Room

Chairmen: William M. Bloom, Chief Fuel Engineer, General Engineering, Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

A. S. Merrow, Assistant Fuel Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

"Nitrogen from an Air-Separation Plant as a Heat-Treating Atmosphere," by B. Herbert, Metallurgist, and J. R. Rink, Research Metallurgist, Research & Development Dept., Inland Steel Co., East Chicago, Ind., and L. R. Chrzan, Laboratory Div. Head, and M. F. Hoffman, Project Engineer, Development Laboratory, Linde Co., Newark, N. J.

"The New 5-Zone Slab Heating Furnace at Campbell Works, The Youngstown Sheet and Tube Co.," by D. C. Haney, Superintendent, Fuel and Power, Youngstown District, and J. B. Mitchell, Assistant Superintendent, 79-In. Hot Strip Mill, Campbell Works, The Youngstown Sheet and Tube Co., Youngstown, Ohio

"New Pits at Acme-Newport Steel Co.," by R. R. Kuhni, Combustion Engineer, Acme-Newport Steel Co., Newport, Ky.

2:00 pm—MECHANICAL SESSION— Urban Room

Chairmen: L. A. Fugassi, Chief Engineer, Midwest Steel Co., Div. of National Steel Corp., Valparaiso, Ind.

S. W. Stouffer, Director of Construction and Maintenance, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Welding—A Versatile and Economical Tool in Steel Mill Maintenance," by J. J. Matusek, Assistant Superintendent, Mechanical Dept., Inland Steel Co., East Chicago, Ind.

"Steel Mill Service Water Studies," by R. H. Anderson, Head, Cleveland Dept., Stanley Engineering Co., Cleveland, Ohio, and K. A. Roddy, Report Group, Stanley Engineering Co., Muscatine, Iowa

"Design Considerations for Belt-Conveyor Systems," by H. Colijn, Senior Technologist, Electromechanical Research, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

2:00 pm—OPERATING PRACTICE SESSION— Monongahela Room

Chairmen: Frank F. Argust, Superintendent, Industrial Engineering, The Colorado Fuel and Iron Corp., Pueblo, Colo.

H. F. Miller, Assistant General Manager, Bethlehem Steel Co., Bethlehem, Pa.

"Capital Investment and Productivity Measurement," by Wm. T. Hogan, S.J., Professor of Economics and Director, Industrial Economics Program, Fordham University, New York, N. Y.

"The Changing Open Hearth," by Edgar B. Speer, Administrative Vice President, Central Operations—Steel, United States Steel Corp., Pittsburgh, Pa.

"Noise Control in the Steel Industry," by James H. Botsford, Noise Control Engineer, Bethlehem Steel Co., Bethlehem, Pa.

7:30 pm—FORMAL DINNER—Ball Rooms

10:00 pm—DANCE—Urban Room

AISE members and guests. No admission charge.

THURSDAY, SEPTEMBER 28

8:30 am—INSPECTION TRIP—

Armco Steel Corp., Butler, Pa. Buses leave from Penn-Sheraton Hotel. Buses will be back to the Hotel at approximately 1:30 pm.

LADIES PROGRAM

Ladies Headquarters and Registration—
Penn-Sheraton Hotel
Parlors E & F

Monday, September 25

9:00 am.....Registration, Parlors E & F
9:30–11:00 am.....Welcome—Coffee

Tuesday, September 26

3:00 pm.....Fashion Show (Saks Fifth Avenue)
Terrace Room
Penn-Sheraton Hotel
4:00–5:00 pm.....Cocktails

Wednesday, September 27

11:00 am–2:30 pm....Brunch at the LeMont
Buses will leave Penn-Sheraton Hotel at 10:30 am
7:30 pm.....Formal Dinner—17th Floor Ball Rooms
Penn-Sheraton Hotel
10:00 pm.....Dance—Urban Room

Honorary Chairwoman: Mrs. C. E. Pritchard
General Chairwoman: Mrs. J. H. Bray
Co-Chairwoman: Mrs. W. J. Wenger

To partially cover costs, a flat registration charge of $5.00 will be made which will cover all ladies activities except the formal dinner on Wednesday evening. This must be paid on registering, when tickets will be issued for these events.

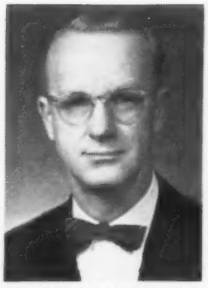
Convention Chairmen

JOHN F. KOSTELAC

JAMES A. B. PINNEY

HUGH J. PUGSLEY

C. H. VAUGHAN


W. A. BLACK

A. B. GLOSSBRENNER

A. E. CICHELLI

C. E. S. EDDIE

ELMER E. BARTHEL

CLAYTON L. SQUIER

C. W. DUNN

F. C. McGOUGH

C. A. ROBERTS, JR.

STEPHEN VAJDA

F. G. KREDEL

R. P. SCHULER

H. W. DORSET

JOHN A. DRGON

WILLIAM M. BLOOM

A. S. MERROW

L. A. FUGASSI

S. W. STOUFFER

FRANK F. ARGUST

H. F. MILLER

ABSTRACTS OF TECHNICAL PAPERS

to be presented at technical sessions of

AISE ANNUAL CONVENTION

PENN-SHERATON HOTEL

PITTSBURGH, PA.

September 25, 26, 27, 28

"RECENT DEVELOPMENTS AND OPERATING EXPERIENCE IN CONTROL OF GAGE AND SETUP OF STRIP MILLS"

by R. E. MARRS, Consulting Application Engineer, Metal Rolling Application Engineering, General Electric Co., Schenectady, N. Y.

R. E. MARRS

△ THE paper sums up the operating experience to date on the most recent installations of both hot strip and cold strip mills and reports on the findings made possible for the first time by the higher degree of instrumentation which characterizes new mills now installed. In addition, many of the requirements which must be considered in the purchase of a new hot strip mill or the modernization of existing mills such as power requirements, mill speedup, adjustable-voltage screwdowns, loopers, etc., are discussed in their interrelationships to obtain a good manually controlled mill. A good manually controlled mill will not only provide immediate benefits in increased productivity but is required before more advanced control systems can be successfully added.

"ON-LINE COMPUTER CONTROL FOR A REVERSING PLATE MILL"

by A. W. SMITH and L. P. GRIPP, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

△ A REVERSING plate mill is a very suitable process for in-line industrial control computers. Card

A. W. SMITH

L. P. GRIPP

programmed control has proved to be quite suitable for other types of reversing primary mills but the wide variety of rolling sequences which are experienced on a reversing plate mill and the fact that the finished product is frequently quite thin make it necessary to go to a more complicated control system. Since the spring of the mill becomes quite large compared to the finished thickness, some allowance must be made in positioning the mill rolls to take care of mill spring if accurate gage is to be maintained. This requires that the computer predict the roll separating force prior to rolling a particular pass and also predict the amount of mill spring which would result so that the screwdown can be properly positioned. This is a particularly difficult procedure on the thinner products where the mill spring is large compared to the delivered thickness and where the temperature of the steel is decreasing at a very rapid rate.

The computer controls the main mill drive and all of the auxiliaries which are closely associated with the mill. Feedback information such as roll separating force, drive motor load, and X-ray thickness gage readings are fed into the computer and used to get maximum production of high quality product without exceeding the mechanical and electrical capabilities of the equipment.

In order to build such a control system it was necessary to make extensive investigations into the char-

acteristics of the rolling of hot steel and the characteristics of the rolling mill as an elastic structure.

"CONTROLS AND INSTRUMENTATION FOR A NEW SINTERING PLANT"

by W. J. TUNNY, Superintendent, Electrical Maintenance, The Youngstown Sheet and Tube Co., East Chicago, Ind.

W. J. TUNNY

Δ AS in the blast furnace, the sintering process is affected by variables such as chemical composition of material inputs, thermal inputs, drafts, temperatures, etc. The process reactions are complex, involving many different variables and sources of process fluctuations. In many respects the progress toward knowledge, and consequent automation of the process, has paralleled the same activity in the blast furnace area. Automatic programming and charging systems for blast furnaces are functionally similar to the automatic proportioning systems for sinter-mix preparation, except the former is a batch process and the latter a continuous process.

The application of automation to sinter plants requires a continual upgrading of conventional electrical equipments such as the means of providing adjustable voltage for the d-c drive motors, regulating control equipment, process controllers, industrial type sensing and computing equipment suitable for the adverse ambient conditions found in sinter plants.

Control for the automated sinter plant is extensive and fairly complex, and is designed for high reliability, ease of maintenance and installation and flexibility.

The instrumentation industry must develop or improve industrial quality sensors that will continuously measure physical and chemical properties of materials in the process. Final objectives, such as increased efficiency, productivity and improved quality of the sinter process, must be kept in mind.

"CONTINUOUS STRIP ANNEALING"

by W. P. GILL, Marketing Specialist, Industrial Heating Dept., General Electric Co., Shelbyville, Ind.

W. P. GILL

Δ STRIP annealing has undergone vast changes in its 25-year history, changes which have increased quality and line flexibility, while decreasing product and maintenance costs.

This paper deals with the various phases of continuous strip annealing covering such items as annealing cycles, application to thin tin plate, types of protective atmosphere, computer control and cooling methods.

The number of continuous lines, installed and on order, is discussed and a comparison is made between domestic and foreign installations (rated speed and production).

A comparison of past and present techniques and the advantages gained by the engineering and design features that have been incorporated in a recent installation are given.

A general discussion of bright annealing of stainless steels is presented to indicate recent annealing developments for special metals.

"CONTINUOUS HEAT TREATMENT OF STEEL PLATE"

by N. K. WILLIS, Director of Engineering, Drever Co., Bethayres, Pa.

N. K. WILLIS

Δ THE continuous heat treatment of steel plate by conveying the product on continuously rotating rolls was first conceived in the late 1930's but did not become a reality until the armament program began for World War II.

Beginning in 1940 about 40 continuous roller hearth lines were installed by the industrial furnace industry for producing light armor plate, largely for tanks, armored cars, airplanes and landing craft. All but three or four of these lines were dismantled and scrapped before or at the conclusion of the war and the continuous production of heat-treated plate by the roller hearth method was practically at a stand-still for several years.

The Korean conflict again brought this method of plate treating to the fore when 13 new lines, all quite similar to those previously built, were installed for the re-armament program, this time to be dismantled but not scrapped at the conclusion of hostilities.

During the 1950's the greatest advance in this method of continuous production took place. Steel companies, faced with the competition of lighter weight materials for constructional purposes as well as foreign competition on ordinary carbon steel plate, developed the weight saving, high-strength, low-alloy harden, quench and temper steels. The introduction of this high-strength steel required high-output continuous equipment for wider plate than was required for tank and car armor if its production was to make it competitive.

It was 1955 before the first high-output line was placed in operation. Since that first effort, the American furnace industry has installed an average of one line each year in the basic steel plants of this country and as many in foreign lands.

The interest in and the use of heat-treated, high-strength steels continues to be great throughout both the domestic and foreign steel industries with the result that the known installed capacity for the full heat treatment of steel plate, not including those facilities built for annealing stainless plate, has risen to the present 400,000-lb per hr capacity for plate 72 to 172-in. wide and up to 3-in. thick.

In the next year alone projects are being considered and some are already on the drawing boards that will add another 100 tons per hr to the world's present

facilities. Unfortunately, however, we here in America will benefit by only a small percentage of that increased capacity.

"CONTINUOUS STRIP GALVANIZING DEVELOPMENTS"

by CARROLL CONE, Vice President—Engineering, Surface Combustion Div., Midland-Ross Corp., Toledo, Ohio

CARROLL CONE

Δ THE paper briefly describes the old sheet galvanizing process and some of the limitations of that process that have been overcome by continuous strip galvanizing. The essential steps in preparation of steel surfaces before galvanizing are described, and four processes for continuous strip galvanizing, now in commercial operation, are compared to illustrate how these steps are accomplished in each process.

Factors affecting coating adherence are discussed. Equipment for producing spangled and wiped zinc coatings is described, along with the process modifications necessary to produce hot-dip aluminum coatings on strip.

This paper is concluded by a description of some of the problems and limitations of present processes and a look at some possible future developments.

"CONTINUOUS GALVANIZING PRACTICES AND TRENDS"

by DEAN W. FERGUSON, General Foreman, Galvanizing, Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

DEAN W. FERGUSON

Δ THE first patent for galvanizing was issued in England in 1837. Approximately 100 years later the first continuous hot-dip galvanizing line at Butler, Pa., began producing sheets and coils with a tightly adherent coating not possible with the existing hand-fed sheet pots. The improved galvanized product opened up new markets and new continuous hot-dip lines were installed so rapidly that, at the end of 1961, the estimated continuous galvanizing capacity will be 81 per cent of the industry total or about 4,900,000 tons per year.

The continuous hot-dip galvanizing line installed at the Pittsburgh works of the Jones & Laughlin Steel Corp. in early 1956 is a typical sendzimir process line. The sendzimir process receives cold rolled coils and anneals the strip in a hydrogen atmosphere furnace which also prepares the strip surface for the coating operation. The excellent adherence of the galvanized sheet is attained by the proper zinc bath composition which includes a small amount of aluminum. The continuous hot-dip line requires trained operators and properly designed equipment to maintain a high-quality, uniform coating and to produce sheets with the proper physical quality for the end use.

The period since 1956 has been an active one for the galvanizing industry with the addition of new capacity, the innovations in equipment design and the continued growth of the market for galvanized products. The market for the standard galvanized product has grown but the special process material has opened new fields. The special process products include various types of surface finish, differential coatings and steels with specific physical requirements. Although the development of improved products has been rapid there is yet more to be accomplished in the areas of weldability, corrosion resistance, paintability and steel physical properties.

"STRIP PROCESSING"

by DONALD A. McARTHUR, Vice President—Engineering, The Wean Engineering Co., Inc., Warren, Ohio

D. A. McARTHUR

Δ ONE of the important changes in the past ten years has been the coiling on the hot strip mill of much heavier material, and the installation of modern coil shearing lines for heavy gage hot rolled strip.

A continuous pickling line of 1961 consists of essentially the same fundamental elements as the continuous pickling line of 1940, but its appearance to the eye is considerably different and the tonnages it produces are radically different.

Probably 99 per cent of all galvanized steel in the U. S. is now made on continuous strip lines. Several different types of lines have been developed, all of which produce a superior product at a lower cost than material previously galvanized in cut sheet form.

In 1940 there was in existence only one full width electrolytic tinning line, which produced less than one half of one per cent of all tin plate. Today over 90 per cent of all tin plate is produced electrolytically. Three different types of lines are in use in various steel companies, all producing an excellent product at a reasonable cost.

One of the most interesting, and most recent, innovations in flat rolled steel has been the production of thin tin plate. Various methods have been considered and tried in the production of this material. Considerable tonnages are being produced every month, and at least one complete new continuous line has been purchased to do the final processing on this material.

Shearing lines have undergone less change than most other strip processing equipment, due in a great measure to the fact that a much greater percentage of material is being shipped in coil form each year. Lines for shearing heavy hot rolled strip from coils are an exception.

Continuous lines refer to lines where, at least theoretically, strip can run through the processing section continuously at one speed. On lines where material is

not severely damaged at every strip stop, a decision whether to make them continuous or start-stop must be made on the basis of economics.

"CRANE RAIL LUBRICATION"

by ELMER E. FLECK, President, and HUGH L. DAVIS, Sales Engineer, Research Appliance Co., Allison Park, Pa.

ELMER E. FLECK

HUGH L. DAVIS

Δ ROUGH, hard usage, misalinement and other factors add to and increase the wear on overhead crane wheel flanges and rails.

Downtime and replacement costs when changing wheels and/or rails on overhead cranes is a very important factor in the operation of any type of heavy industry today. The reduction of this cost, at slight investment, should be of interest.

In the past, lubrication of the flanges and rails had been done by hand, using a stick or brush to apply the grease or oil. This helped, but was not carried out on a routine schedule and over long periods proved inadequate.

Present methods vary in that one applies the lubricant to the wheel flanges, the other to the rail sides.

The application of a small, safe amount of lubricant to the sides of the rails by means of automatic lubricators will increase the life of the wheels and rails many times and in some cases eliminate the need for maintenance.

With proper lubricants and centralized automatic lubrication, one of the major maintenance problems with heavy-duty overhead cranes is reduced to a minimum.

"EFFECT OF FIRE-RESISTANT FLUIDS ON DESIGN AND OPERATION OF HYDRAULIC SYSTEMS"

by WILLIAM M. SCHREY, Field Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

WILLIAM M. SCHREY

Δ FIRE-resistant fluids are replacing petroleum products in many hydraulic systems in the steel industry. More and more fire-resistant hydraulic fluids are being developed and marketed. Each year the number of conversions to these fluids increases. Many of the early conversions were successful. Of the more recent ones that the author is aware of, all have been successful. Future conversions will meet with success when all the contributing factors are properly evaluated. This paper enumerates the factors that contribute to a successful conversion by showing the effect of fire-resistant fluids on the design and operation of hydraulic systems.

"THE SELECTION AND EVALUATION OF ROLLING OILS"

by R. W. KENYON, General Sales Manager, Kerns United Corp., Chicago, Ill.

R. W. KENYON

Δ TO date there is no proved laboratory method for determining which rolling oil will give the best performance on any particular mill.

Only by test runs on the specific equipment used can a true evaluation of the merits of a rolling oil be ascertained. Too often final evaluation is a report of someone's personal opinion and not a report of facts.

The cold reduction mill and the rolling oil manufacturer each have definite responsibilities in the proper selection and true evaluation of a rolling oil. The user must furnish the supplier with the information necessary to determine if his product can be expected to improve the operation. He must also have available certain data which he can use in comparing the final results of the test.

The supplier should be fully qualified to analyze the information supplied by the user and make a recommendation that will be compatible with the equipment and specific requirements related to the products produced. He must also arrange to have personnel in attendance during the test who are capable of observing the operation and suggesting improvements in handling, application and operating practices which will assist the user in obtaining a true evaluation of the product being tested.

This paper: (1) defines the information required by the supplier to make a sound recommendation, (2) describes the means of obtaining factual data and current performance records, (3) outlines responsibilities of the supplier during the test and (4) explains the areas important to the user when comparing test data with available performance data.

"ELECTRICAL PROTECTION ON HIGH-CAPACITY SYSTEMS"

by PAUL S. POTTER, Electrical Engineer, Bussmann Manufacturing Div., McGraw-Edison Co., St. Louis, Mo.

PAUL S. POTTER

Δ THE function of electrical protective devices has become more important and more complex. At the secondary voltage level, main circuits are now commonly loaded to continuous current values in the order of several thousand amp. Expansion of supply capacity to carry these loads has introduced an increasing hazard due to the fault currents available, which are found

to be as high as 100,000 to 200,000 amp on many network systems. Unless properly handled, such fault currents can impose terrific damage on circuits and apparatus, by magnetic forces and heat.

Overload protection for apparatus has become more specialized. Operating characteristics vary for different types of equipment, and protective devices with matching characteristics are needed to insure safe operation while providing maximum continuity of service. A device which would give the best protection for one type of equipment might not have the proper time-current response to be satisfactory for another type.

The paper discusses the sources of high-fault current, and describes the construction of high-interrupting-capacity, current-limiting fuses which are available for present conditions of loading and fault levels. Typical examples illustrate the advantage of overload protection having precise response to match the needs of specific equipment. Finally, some of the conditions are considered for the selection of overcurrent devices to provide co-ordinated service on a secondary distribution system.

"APPLICATION OF CIRCUIT BREAKERS WITH SYMMETRICAL RATINGS IN STEEL MILLS"

by PHILIP L. CAMP, Manager, Low Voltage Engineering, I-T-E Circuit Breaker Co., Philadelphia, Pa.

PHILIP L. CAMP

Δ INCREASED reliability is being designed into industrial power systems by the use of high-speed relaying and fast-clearing circuit breakers.

The application of power circuit breakers under these conditions is complicated by the fact that breakers are presently rated on an asymmetrical basis. Multipliers must be applied to fault calculations to factor in actual breaker operating times since a considerable degree of circuit asymmetry may still exist at the time the fault is cleared.

Methods of rating power circuit breakers on a symmetrical basis have been developed which will simplify their application. These methods have the effect of building allowances for circuit asymmetry and contact parting time into the breaker rating.

In comparing the proposed symmetrical basis of rating with the existing asymmetrical basis, several changes in terminology are noted. Chief among these is the substitution of the term "rated short-circuit current" for the term "rated interrupting mva" and the introduction of (K) the "voltage range factor."

The factor (K) is used to determine the maximum symmetrical interrupting current, the minimum voltage to maintain full interrupting capacity and the closing and latching ability.

In order to "build in" to the circuit breaker rating the allowance for speed of contact parting, it has been necessary to assume a practical maximum degree of circuit asymmetry. A circuit with an X/R ratio of 15 has been chosen.

The usual industrial plant will very seldom have a power system whose X/R ratio will exceed 15. Circuit breaker application is, therefore, made easy. Simply divide the system voltage by the system impedance and the resulting symmetrical current can be directly compared to breaker ratings.

Steel mills, however, with their concentration of heavy rotating equipment, may very well produce circuits whose X/R exceeds 15. The asymmetrical current in the first half cycle after fault now becomes the limiting factor rather than the interrupting current and special consideration is required to properly apply the circuit breaker.

A factor of 1.25 has been derived which, when applied to the calculated short-circuit current, gives a value for comparison with breaker ratings adequate for all practical degrees of asymmetry.

"ELECTRICAL LOCKOUT PROCEDURES"

by J. R. LAMBERTON, Electrical Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

J. R. LAMBERTON

Δ THE basic purposes for a lockout procedure of any kind are personnel and equipment safety. With these in mind, engineering is required to provide lockable disconnecting devices in the power supply to electrically actuated equipment to provide adequate protection and convenience for operating personnel, and for maintenance and other service personnel who are not concerned with electric shock hazards. The same, or additional disconnecting devices, are required to protect electrical personnel from shock hazard in servicing power distribution systems and motor control equipment.

Procedures for the use of the lockout devices are the result of the combined thinking of operating, engineering, maintenance and safety supervision. They usually consist of three sets of instructions, one for the safety of operating people in the performance of routine duties, a second for maintenance and service people to make areas safe from the hazards of mechanical movement, and a third for the elimination of electric shock hazard as well as mechanical movement hazard for electrical personnel.

Whether these instructions are simple or complicated is a function of the complexity of the equipment, since the cost of installed disconnecting devices tends to limit their installation to the minimum quantity necessary.

"GAS ANALYSIS APPLIED TO BLAST FURNACES"

by J. F. TRIOLO, Application Engineer, Iron & Steel Div., Bailey Meter Co., Bala-Cynwyd, Pa.

Δ THE successful evaluation of blast furnace process depends upon acquisition of reliable data. This infor-

J. F. TRIOLO

mation takes many forms, but this paper is limited to that relating to gas analysis. Until recently, either the instrumentation was not available, or if available, they were not actively applied for this service. However, with increased emphasis on blast furnace evaluation, blast furnace gas analysis has assumed new importance.

This paper is a survey of the available instrumentation for this application, with emphasis on principles of operation, sampling systems and location of sampling points. Some representative charts are shown.

Similar consideration is given to the use of waste gas analyzers in connection with blast furnace stove firing.

"COMPUTERS IN FUEL AND UTILITIES DISPATCHING"

by LEE I. DICKINSON, Fuel Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

LEE I. DICKINSON

△ THIS paper deals with the monitoring of the fuel, steam and power system of an integrated steel plant by the use of a digital computer. It covers the reasons for the choice of the computer and how it is used in this application. It then follows the logical steps of monitoring of individual systems by the use of recording charts and log sheets by an individual located in a somewhat remote part of the plant, and then brings the thinking on this through the assembling of this information in a large scale central dispatching station using recorders. Improvements in system have expanded use of data loggers, and finally the use of the digital computer.

The paper points out the advantages of the use of a computer in the projection of purchased power for the demand period as well as for the continuous monitoring of pressure and volume of four gas systems, two water systems, an extensive compressed air system, three interrelated steam systems, as well as the purchased power and home generated power system for the Lackawanna plant.

"MODERN BLAST FURNACE BLOWING AND GAS RECOVERY SYSTEMS"

by C. W. DUNN, Superintendent, Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

C. W. DUNN

△ THE paper is a projected yet fundamental approach to future blast furnace blowing and gas recovery requirements and the author's impression of how these requirements should be met. The entire system from the blower drive to final blast gas usage is considered. Emphasis is placed on achieving maximum system efficiency and optimum process gas utilization.

A discussion is presented on blast furnace gas turbines with the inherent advantages listed for its use as the motive power in the blowing process.

Cost and operational comparisons are illustrated for axial and centrifugal blowers with a primary emphasis on the variable stator axial machine. Identical turbine drives are used on both the axial and centrifugal so that only the blowing end is compared. The conclusions comprehend both favorable and adverse operating conditions for the blowing units.

In the discussion, a cost analysis is also presented of heat retention and utilization from blast air main insulation and the employment of stack recuperators for heating combustion air to the blast furnace stoves.

The final presentation is the author's projection into the future and the coalescence of all these concepts to obtain maximum system reliability and efficiency.

"NATURAL GAS INJECTION AT GREAT LAKES STEEL BLAST FURNACES"

by WILLIAM H. COLLISON, Plant Superintendent, Blast Furnaces and Coke Works, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Mich.

W. H. COLLISON

△ THE paper reports on eight months of experience with gas injection through the tuyères of blast furnaces of Great Lakes Steel Corp. Equipment for gas injection is simple to install and operate, and the cost of installation is comparatively low. Worthwhile savings in coke consumption and cost of iron production are reported. Some increase in production and a smoother furnace operation are noted. Indications of limitations in the use of natural gas are compared with computed curves on those limitations.

"THE INJECTION OF AUXILIARY FUEL INTO THE BLAST FURNACE"

by DR. JULIEN RAICK, Consulting Engineer, Brussels, Belgium

DR. JULIEN RAICK

△ OVER the years blast furnace scientists, engineers and operators have successively brought forth numerous improvements in the traditional blast furnace process, resulting in considerable increases in production and reductions in coke requirements, with some saving in over-all operating costs. These changes have consisted of increases in furnace sizes and improvements in equipment used. Also, improvements in coke and iron-bearing materials, both as to analysis and sizing have been included. These latter improvements clearly have been aimed at improving the material phase or the descending component of this counter-current proc-

ess. The ascending gas phase has only recently been experimented with by the addition of moisture with or without oxygen. Changes in hot-blast temperature have not altered the analysis of the gas phase. The moisture additions have increased the hydrogen content of the ascending gas current.

Recent experiments with hydrocarbon additions at the tuyères are discussed and computations are made based upon the theory of thermodynamic equilibrium in the blast furnace.

From these it appears that the results of fuel injection in the tuyères will be only 15 to 20 per cent of the results when using our double-injection process. This process is described fully in the paper, and consists of injection of a preformed gas using oxygen and hydrocarbon fuel at the bottom of the reduction zone at a critical temperature, and the injection of oxygen or oxygen enriched blast in the tuyère zone in exact balance with the preformed reducing gas injection in order to maintain the thermodynamic equilibrium. In addition to increased production and decreased fuel requirements the capital cost will be reduced.

"SINTERING FANS—SELECTION AND DESIGN CONSIDERATIONS"

by GERALD J. DURNING, Chief Engineer, The Green Fuel Economizer Co., Inc., Beacon, N. Y.

GERALD J. DURNING

△ IN the past few years, the main sintering fans used in the steel industry have aroused considerable attention due to various performance, structural and design problems encountered as a result of the rapid growth in physical size of these units. This paper deals with some of the more important considerations in the selection and design of fans for this application. Centrifugal fans for sintering have hitherto been confined largely to the straight radial "steel plate" type and reference is made to the history of this design.

Recent utilization of modern design trends, involving the introduction of all welded wheels with blade shapes other than straight radial, are shown to have their effect on the economical design of fans of much higher efficiency than is possible with the radial blade type. These blade shapes are discussed and illustrated, along with their influence on the noise level problem.

A discussion of structural design is included together with practical considerations and other very important, if less obvious, factors are also dealt with, notably fatigue.

Emphasis is placed on the salient points of correct selection, the exacting structural demands of the application and the advantages of different basic designs in terms of performance, structural reliability and operating economy, with attention to such items as noise level, wear, vibration and efficiency.

Treatment of realistic performance requirements based on true density at the fan inlet is incorporated in the form of an appendix.

"DESIGN AND PERFORMANCE OF RECENT DEVELOPMENTS IN BAR MILL COOLING BEDS"

by WM. K. STAMETS, JR., President & General Manager, Northeast Ohio Machine Builders, Inc., Columbiana, Ohio, and J. RALPH DYE, Works Manager, Milton Steel Div., Merritt-Chapman & Scott Corp., Milton, Pa.

WM. K. STAMETS, JR.

△ COOLING beds designed with close centered continuously moving chain are especially suited for handling reinforcing bar. The design is such that the bars are continuously rotated during cooling, thereby assuring uniform cooling, straighter bars and more production through the additional cooling effect. A unique bar kick-out mechanism consisting of a 4-bar linkage is employed for synchronizing the hot runout conveyor with the chain bed attachments. A similar mechanism is used for gathering the cooled bars to make up a shear load and to permit the bed to run without interruption. Included in the paper is a discussion of sag tests performed on hot reinforcing bar under laboratory tests.

"TECHNOLOGICAL EXPLOITATION OF THE STRETCH-REDUCING PROCESS"

by DIETER HANCKE, Vice President—Sales, and ROBERT HARTENSTEIN, Vice President—Engineering, Mannesmann-Meer, Inc., Youngstown, Ohio

DIETER HANCKE

ROBERT HARTENSTEIN

△ THE paper gives a comprehensive history of the employment of the stretch-reducing process in the tube industry with references to previous technical papers. The development of the controversy between 2-roll and 3-roll stands and between individually adjustable and restricted commonly adjustable mill drives will be outlined before the background of reducing mill theory. The fact that the 3-roll mill concept has recently been adopted by a second major steel producer in the U. S. is an indication of the tremendous potential of this process in combination with electric resistance welding.

Recent developments in the handling of thin-wall pipe at very high reductions are discussed together with the requirements in mill design and operation resulting from these major advancements. The reasons why the industry in general has been lagging behind European mills in the application of this process and the exploitation of its potential are critically evaluated.

The high speeds of production possible for small diameter thin-wall pipe require major steps in de-

velopment of subsequent pipe handling facilities from flying saws all the way through pipe finishing equipment. Some recent design developments are discussed and the need and direction for further advancements are outlined. The transfer of experiences in this field to high-speed rolling and handling of solid bars should prove stimulating.

An outlook into the future deals with the basic facts surrounding the application of this process for the manufacture of electric resistance welded pipe: unit cost of production; economy; degree of automation; possibility of higher welding speeds; high quality of product as a result of strip tolerances for wall; and 100 per cent slow-speed nondestructive testing, in the weld mill, of large sizes before rolling down to finished product at high speed.

"PASS REDUCTION SCHEDULE FOR OPTIMUM PRODUCTION FROM HOT STRIP MILL"

by DR. BETZALEL AVITZUR, Research Engineer, Applied Science Dept., Scientific Laboratory, Ford Motor Co., Dearborn, Mich.

DR. BETZALEL AVITZUR

△ IN tandem mill operations, a strip of original thickness (t_0) and width (b) is reduced to a final thickness (t_p). The process is continuous, and the volume rate that passes through each mill is identical. Since the strip's width remains practically constant, the condition of volume rate constancy imposes a dependence of the strip's speed on its thickness. The volume rate and reduction determine the power requirements from each rolling station. Optimization of the process means a choice of such reduction distribution between the rolling stations that will maximize the volume rate for total reduction from thickness t_0 to t_p. When this is obtained, all stations operate at optimum power capacity.

In the paper a procedure to optimize tandem mill operation is developed. The approach is valid for cold strip rolling as well as hot strip rolling. The example in the paper, however, involves rolling on a 6-stand hot mill.

"MOTOR HEATING EFFECTS OF REACTOR TYPE CONTROL SYSTEMS FOR A-C CRANES"

by J. A. HALVORSON, Electrical Engineer, Bridge & Crane Control Section, Cutler-Hammer, Inc., Milwaukee, Wis.

J. A. HALVORSON

△ CURRENT interest in reactor-controlled a-c crane drive systems stems from a number of features offered which are generally unobtainable with the more conventional contactor type a-c systems. Among the most significant of these features are the following:

1. They can be made essentially static.
2. They offer excellent speed control.
3. They can provide stepless control, including "float" control, whereby the load on a hoist can be held motionless by motor torque alone without setting the brake.

Various types of systems have been used or proposed using primary-controlled saturable reactors, primary-controlled or fixed ratio transformers, secondary-controlled or fixed reactors and primary and secondary contactors and resistors. A given system normally includes a number of these power components in combination. It is not the purpose of the paper to consider the relative merits of the various systems from a performance point of view, but rather it limits its scope to a consideration of only the increased motor heating effects that such systems produce.

If reactor type crane control is selected because of its speed control feature, then it is reasonable to assume that appreciable operation at reduced speed is expected. Speed and torque of a wound-rotor motor can be controlled by the use of reactive components in either the primary or secondary or both. In any case, some sacrifice in motor efficiency is required to obtain torque at reduced speed.

The paper explains the reasons why such adverse motor heating effects are produced, how they affect crane operation and to what extent good crane control design can minimize them.

"SOMETHING DIFFERENT IN REACTOR CRANE CONTROL"

by C. A. SCHURR, Supervisor of Systems Development Section, EC&M Div., Square D Co., Cleveland, Ohio

C. A. SCHURR

△ RECENT installations of reactor controls for application to a-c cranes have indicated both good and bad features. The good points in general have been concerned with operating characteristics where it has been clearly demonstrated that good speed control and response have been possible. The characteristics have in many cases been superior to those achieved with more conventional a-c and d-c controls.

The undesirable features have been concerned with more complicated motor and control selection procedures, motor heating, poor power factor, collector system deficiencies, safety considerations, heavy equipment and installation adjustments.

A study of these problems has led to an improved type of control for both hoist and traverse drives for a-c cranes using wound-rotor motors, and in some cases, squirrel cage motors. The control includes a unique power amplifier which incorporates the most desirable characteristics of conventional saturable core reactors and self-saturating magnetic amplifiers. It has been possible to produce a more efficient amplifier with fast response and of less weight than with more conventional arrangements. The physical construction of the amplifier permits simplification of fabrication procedures and results in lower cost standardized components which considerably minimizes the user's

investment in spare parts.

Improved control circuits make more effective use of semi-conductor devices where high reliability is realized.

The fast response of the system has permitted the design of regulated systems with a significant reduction in stability problems. This consideration is important in reducing installation time and expense.

For hoist applications where static reversal is desired, a study was made to determine the relative merits of various combinations of fixed impedances in the rotor circuit. The results indicate that appropriate slip resistors will produce desirable features which in some respects incorporate the characteristics of dynamic lowering d-c series motor applications. It is necessary to consider a different method of specifying performance and motor selection to take full advantage of these characteristics and this paper considers this problem.

Reversing drives, such as traverse motions, can be powered with a-c wound-rotor motors where speed and torque control is accomplished with the new power amplifier in the rotor circuit. Here again the improved efficiency, the high speed of response and the lighter control equipment improve the "feel" and minimize installation difficulties.

This paper describes typical circuits for hoists with static power reversal, stepless speed control and for use with control or power circuit limit switches. It also describes circuits for control of reversing drives which are ideal for use on traverse motions. These systems are not limited in application to crane drives. A detailed description of the new power amplifier is included along with some measured characteristics.

"THE CRANE OF THE FUTURE"

by F. M. BLUM, General Sales Manager, Industrial Div., Harnischfeger Corp., Milwaukee, Wis.

F. M. BLUM

△ THE crane of the future for the steel industry is actually being built today. Cranes are being built for the cement industry which incorporate many features the steelmaking industry should adopt. The steel industry, however, is sitting back, waiting to have someone else prove the newer concepts and designs in crane building. The cement industry puts cranes to very severe service. In clinker storage operation, the entire cement mill depends upon the continuity of performance of the crane. These cranes are built every bit as rugged as the heavy-duty cranes for the steel industry. Therefore, the test of the new innovation in the cement industry should leave no doubt in the minds of the steel industry as to the reliability of the crane of the future.

Many of the ideas presented in the paper are not new, but are adopted from the German steel industry where they have been used successfully.

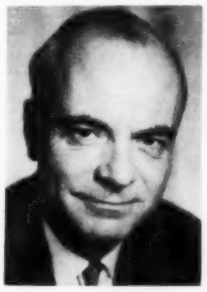
The crane of the future will be powered by a-c motors. Our company's experience in the production of heavy-duty cranes for the cement industry has been approximately 98 per cent a-c equipment, and slip ring motors up to 250 hp have been designed for this service. With these motors, AISE brakes have been used operated in conjunction with rectifiers. The control has seen the greatest progress: from manually operated control to semi-magnetic control, to full magnetic counter-torque control. Stepless electronic control was developed for bridge and trolley service and stepless electronic variable-voltage control for the holding and closing line and, now, there is stepless static control.

This advancement in electrical components has brought the a-c crane on a par with the d-c crane, both in performance and maintenance.

Changes in the mechanical structure of the crane involve "walk-in" pressurized girders, with all the control mounted inside of one of the crane girders. The pressurization makes it weatherproof and dustproof. Individual drives for the bridge on all four corners of the crane will be standard. There will be no more cross-shaft drives and no more yearly discussions on the virtues of a straight tread vs a tapered tread bridge wheel. Flangeless bridge wheels will be used and the crane held in alinement by side guide rollers contacting the side of the head of the rail. The elimination of bridge conductors by substituting festooned cables is a big step to eliminate wear and maintenance and replacement of contact shoes and to assure continuity of electrical contact at all times.

"THE A-C MILL MOTOR—A NEW AISE STANDARD"

by MALCOLM B. ANTRIM, Chairman, AISE Mill Motor Committee, and Manager, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.



M. B. ANTRIM

△ THE paper covers the proposed ratings, horsepowers and speeds for the new standardized a-c mill motor. It covers dimensions and bearing sizes and deals with the reasons for the selections of these various standardizations by the mill motor committee. Since this new standardized a-c mill motor will be the subject of a membership vote in the near future discussion concerning all of the points presented is welcomed.

"NITROGEN FROM AN AIR-SEPARATION PLANT AS A HEAT-TREATING ATMOSPHERE"

by B. HERBERT, Metallurgist, and J. R. RINK, Research Metallurgist, Research & Development Dept., Inland Steel Co., East Chicago, Ind., and L. R. CHRZAN, Laboratory Div. Head, and M. F. HOFFMAN, Project Engineer, Development Laboratory, Linde Co., Newark, N. J.

B. HERBERT

△ THE availability of high-purity nitrogen from air-separation plants led to an extensive investigation to determine the factors governing the successful application of this gas as a protective heat-treating atmosphere.

Nitrogen atmospheres containing controlled amounts of oxygen and hydrogen were investigated as the prospective

J. R. RINK

L. R. CHRZAN

M. F. HOFFMAN

atmospheres in a continuous annealing line and radiant-tube box annealing furnaces. The experimental work consisted of 39 tests: three tests on a continuous annealing line involving a total of 269 tons of steel, and 36 tests on large, 6-hearth box annealing furnaces involving a total of 8709 tons of steel. During each test the incoming gas composition and annealing temperatures were continuously measured, and the flow of the incoming gas and the composition of the exhaust gases were periodically measured. These full-scale annealing tests show that a nitrogen protective atmosphere containing less than 10 ppm oxygen can be used successfully without the addition of hydrogen. If the oxygen content exceeds 20 ppm, the steel oxidizes even with a hydrogen content as high as six per cent by volume. Properties of tin plate annealed in nitrogen are equal to the properties obtained in normal practice with generated atmospheres.

"THE NEW 5-ZONE SLAB HEATING FURNACE AT CAMPBELL WORKS, THE YOUNGSTOWN SHEET AND TUBE CO."

by D. C. HANEY, Superintendent, Fuel and Power, Youngstown District, and J. B. MITCHELL, Assistant Superintendent, 79-In. Hot Strip Mill, Campbell Works, The Youngstown Sheet and Tube Co., Youngstown, Ohio

D. C. HANEY

J. B. MITCHELL

Δ THE paper discusses the design and construction of the new 5-zone slab reheating furnaces at the Campbell works of The Youngstown Sheet and Tube Co. This installation was a part of the 79-in. hot strip mill modernization program.

These furnaces are designed to heat slabs ranging in thickness from 5-in. minimum to 10-in. maximum and in length from 118 to 144 in. for double row operation to 276 to 312 in. for single row operation. Present maximum slab width is 55 in. with future widths up to 76 in.

Space restrictions made it necessary to limit the furnace installation to three furnaces. Additional furnaces would have required extensive and costly relocation of other facilities. The basic problem, therefore, was that of providing a furnace design which would give very high heating capacity without sacrifice of quality.

A study was made of the design and performance of other slab heating furnaces in a number of plants. The requirements were also discussed with furnace builders and the suppliers of auxiliary equipment. Rigid specifications were then prepared as to furnace contour, combustion volume of each zone, application of burners, preheated air temperature, type and size of recuperators, combustion air fan capacity and pressure, stack draft required and instrumentation and controls.

The performance of the furnaces during the short period they have been in operation have confirmed expectations as far as heating quality and capacity. Fuel rates have been exceptionally good even under staggered mill operating schedule.

"NEW PITS AT ACME-NEWPORT STEEL CO."

by R. R. KUHNI, Combustion Engineer, Acme-Newport Steel Co., Newport, Ky.

Δ AS far as is known Acme-Newport Steel Co. has the only soaking pit installation which permits a direct comparison between cold air and recuperative pits.

In this new installation one pit is equipped with recuperators and three pits use cold air. There are no structural differences between the pits. Identical temperatures are maintained. The fuel and air meter systems and the instrumentation are the same, and the flue systems consist of a common flue and stack with individual pressure control.

The maximum fuel rates are set so that the same charge will be brought to rolling temperature in the same time: 20 MM Btu for the cold air pits and 17 MM Btu for the recuperative pit. Exactly equal heats are charged since split heats are worked making possible equal track time charging patterns.

Therefore, since cold air and preheated air are the only concernible difference, it is believed that the savings resulting from preheated air can be properly evaluated.

Along with this comparison there are some interesting control features: the ability to switch rapidly from gas to oil, temperature control and recuperator control.

"WELDING—A VERSATILE AND ECONOMICAL TOOL IN STEEL MILL MAINTENANCE"

by J. J. MATUSEK, Assistant Superintendent, Mechanical Dept., Inland Steel Co., East Chicago, Ind.

J. J. MATUSEK

Δ CONTINUED progress in new developments and technological advances in welding in recent years have produced a variety of welding processes, which have proved to be great assets in steel mill maintenance.

Steel mill equipment is usually large, costly, intricate in design and above all, from a maintenance angle, it is part of an "assembly" line whose downtime

could possibly run into thousands of dollars per hr. As a result of the severe operating conditions, equipment is subjected to terrific wear and abnormal mechanical fatigue failure, and the fundamental maintenance problem is the rapid and economical replacement of worn or broken parts.

People who are responsible for the maintenance of equipment in a large steel mill are thoroughly aware of such problems and are constantly vigilant for ways and means to improve existing conditions through the utilization of modern tools or processes related to their problems.

This paper acquaints maintenance personnel, in a simple and nontechnical manner, with some of the recently developed or improved welding processes now being used for steel mill maintenance.

The welding processes covered, and their applications, are directly related to steel mill maintenance and are presently so being utilized. As a result of the extended variety of welding applications, more work is turned out, flexibility is increased, the scope and magnitude of maintenance coverage is enlarged, delays are minimized and above all costs are reduced.

Some of the specific items covered are: reclamation of rolls by automatic submerged arc welding, hardfacing of mill spindles and coupling boxes by the open arc processes; welding of blooming mill shear knives; and reclamation of copper scarfing machine units and miscellaneous bronze parts by inert gas are welding.

Planning the job for welding, both in the shop and in the field, plays an important role in time savings and ultimate cost reduction. Some practical ideas relative to this particular phase of maintenance welding are also discussed.

"STEEL MILL SERVICE WATER STUDIES"

by R. H. ANDERSON, Head, Cleveland Dept., Stanley Engineering Co., Cleveland, Ohio, and K. A. RODDY, Report Group, Stanley Engineering Co., Muscatine, Iowa

R. H. ANDERSON

K. A. RODDY

△ THE paper deals with investigations, studies and analytical procedures undertaken to determine economical solutions to service water system problems. Some of these problems reflect actual difficulties existing in a mill; but more often they result from increased water requirements for expanding production facilities.

To determine a sound basis for system improvements to meet the increased demands, studies are undertaken for the following purposes:

1. To establish a feasible over-all policy for development and operation of the system upon which integrated planning for service water use throughout the works can be based.
2. To determine specific measures, consistent with the over-all policy, required to meet immediate problems.
3. To determine the type of improvements, also consistent with the over-all policy, to be undertaken in various areas of the works as need arises.

Three distinct phases are evident in such a study:

1. Field surveys.
2. Analysis of field data.
3. Development of improvements which will provide for immediate water requirements in a manner compatible with long-range system development.

The field survey may require from a few days to a few weeks. Several hundred pitot traverses may be performed. A record of mill operations indicating the working shifts and downtimes of all production equipment is correlated with the survey.

Analysis of the data collected in the field survey is the second phase of the study. This analysis includes the determination of pipe coefficients, determination of the equivalent length of pipe runs, correction of pressure data to a common datum, reduction of the pitot data and tabulation of system demands at each point of use.

The hydraulic characteristics of the entire existing system now may be completely defined. With the demands on the distribution system known, the system is analyzed by the Hardy Cross method to obtain an exact flow distribution in the network of pipes. Electronic computation simplifies the procedure.

The final step in studying the problems of a service water system is analysis of the present and future water requirements and determination of how best to meet these requirements. The approach to this phase of the study differs little from the approach to most engineering problems. From a number of possible solutions, the engineer must select an improvement program.

The most economical development of water system facilities to provide adequate service is the guiding criteria in the selection of a basic water use policy.

"DESIGN CONSIDERATIONS FOR BELT-CONVEYOR SYSTEMS"

by H. COLIJN, Senior Technologist, Electromechanical Research, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

H. COLIJN

△ MANY a conveyor belt is failing prematurely, not always because of improper belt selection, but frequently due to improper design and engineering of the belt-conveyor system. Generally, 30 to 40 per cent of the total cost of the belt conveyor is represented by the actual belt itself. This expense reoccurs every time a belt is replaced; therefore, over the total life of the belt-conveyor system the cost of belting alone becomes a few times that of the original cost of the total system.

In the designing of a belt conveyor, mistakes of judgment and errors in design occur. They are not all equally serious and most of them can be corrected dur-

ing erection. But there are some that allow no chance for a second guess. These are usually related to belt carrying capacity, belt incline and belt loading points.

This paper discusses in general terms the proper selection of conveyor belting and indicates the engineering and design considerations specifically for loading points that will result in an increase of belt life and consequently a decrease in cost per ton of material handled.

Because much information on the components of a belt conveyor is available in the published literature, the paper does not discuss the design of these components in detail. The emphasis is on the greater use of systems engineering in belt-conveyor design.

"CAPITAL INVESTMENT AND PRODUCTIVITY MEASUREMENT"

by WILLIAM T. HOGAN, S.J., Professor of Economics and Director, Industrial Economics Program, Fordham University, New York, N. Y.

WILLIAM T. HOGAN, S. J.

△ DURING the past 30 years the question of productivity and its measurement has assumed greater and greater significance in our economy. Increasing productivity has been considered by many to be the barometer of economic well being. Thus it is of prime importance that the measurements we use in establishing productivity reflect the actual state of affairs.

Up to the present time the accepted measurement for productivity has been output per manhour. This, however, has been recognized by many as inadequate, because productivity is a ratio or a relationship between all of the input factors in production (labor, raw materials and capital equipment) and the resulting output or product.

It has been generally recognized that increases in productivity, for the most part, are the result of capital investment, yet this input factor does not enter into the measurement figure. The manhour output figure, currently in use, shows increased productivity brought about usually by the installation of improved machinery and equipment. It is therefore important that some standard be developed to measure and evaluate the contribution of capital to productivity. This is a difficult and complex task for capital equipment is a heterogeneous factor since each machine often differs from its predecessors in cost, performance and in the contribution it makes to total productivity.

This paper attempts to analyze and evaluate the contribution of capital to productivity in the steel industry.

"THE CHANGING OPEN HEARTH"

by EDGAR B. SPEER, Administrative Vice President—Central Operations—Steel, United States Steel Corp., Pittsburgh, Pa.

△ THE open hearth is still the largest and most versatile producer of steel and accounts for 85 per cent of the steel made in this country. This paper relates the changes and technological advances which have enabled this process to maintain its leading position and compete economically with more recently developed methods, such as the pneumatic processes made possible by the availability of low cost oxygen.

EDGAR B. SPEER

Also discussed are some of the current and future developments which are being considered to further improve the productivity and economics of the process.

"NOISE CONTROL IN THE STEEL INDUSTRY"

by JAMES H. BOTSFORD, Noise Control Engineer, Bethlehem Steel Co., Bethlehem, Pa.

JAMES H. BOTSFORD

△ INDUSTRIAL noise has attracted the attention of management as a result of the partial deafness which may develop from prolonged exposure to excessive noise in employment. This occupational hearing loss is an occupational disease which is compensable under the workmen's compensation laws of several jurisdictions. Also, zoning ordinances placing limits on noise generated by industrial land uses are being adopted by an increasing number of municipalities. These circumstances create problems which are solved most satisfactorily by noise abatement and engineers should be prepared to provide the engineering assistance required.

Noise is a slight, rapid variation in air pressure which can be measured with calibrated instruments. For engineering purposes, the frequency as well as the intensity of the sound must be determined. Outdoors, sound levels diminish with increasing distance from the source; indoors, reverberation produced by reflections from walls augments the sound arriving directly from the source producing higher levels.

Noise abatement at existing operations may be approached along several lines. Sometimes it is possible to utilize a quieter process such as grinding instead of chipping. The noise source might be modified so as to produce less noise, i.e., noise radiated from a vibrating surface may be reduced by damping the vibration. Also, noisy air exhausts or intakes may be quieted by installation of mufflers. In some cases, noise from equipment may be contained within enclosures. Varying degrees of noise reduction may be obtained in industrial buildings by application of sound absorbing materials to the interior surfaces.

It is usually more practical to avoid excessive noise by proper planning. Efforts should be made to obtain quieter equipment and utilize quieter processes. Operations should be engineered to isolate noisy operations. Sound absorbing construction materials should be used for buildings which will house noisy operations.

By consideration of noise in planning future operations and application of noise control methods at existing operations, engineers can do much to eliminate the noise problems of industry.

New Inspection Techniques and Their Effect on the Mill Operator

. . . . the availability of nondestructive testing methods which can be used at almost any point in the production cycle, in addition to final product testing, can aid in making greater quality control requirements, increase production and reduce costs . . . .

by G. P. MICHALOS
Superintendent of Inspection
Steel and Tube Div.
The Timken Roller Bearing Co.
Canton, Ohio

THE mill operating supervisor, over the years, has developed into a rather versatile individual. His talents must embrace many facets of the over-all picture of steel production. Even though he has at his disposal the skill and advice of numerous specialists, both technical and nontechnical, he must still have a basic understanding and knowledge enabling him to handle an imposing list of problems ranging from the technical means of production to those involving human relations and industrial psychology. With the many rapid advances in technology being made, the mill operator must also be flexible in his approach and acceptance of any methods improvements.

Another problem has been added to this formidable list. The problem of subjecting his product to nondestructive test methods, and these new inspection techniques have had an effect on the mill operator. However, before entering into a discussion of some of these effects, a few typical applications of nondestructive test methods in the steel industry should be cited.

In general, two factors have governed the application of nondestructive test methods in the industry. The first has been to assure the ever increasing demand for better quality. The demands by the armed services, the atomic energy program and the chemical and oil industries for material from which components capable of operating at higher speeds, higher stresses and higher temperatures and pressures can be fabricated, have required many mills that wished to remain in a competitive position for this class of business to become familiar with and adopt new inspection techniques.

The second and probably more significant factor has been the possibility of reducing production costs. The extent to which this can be achieved should provide the ultimate answer as to how widespread the industry adopts the new inspection techniques. No company would consider employing an engineer, installing a new piece of equipment or a new working method unless there was a reasonable assurance that the results would prove to be profitable in one way or another. The steel industry has adhered to this common sense rule in its approach to nondestructive testing. The advent of certain nondestructive tests that are capable of being applied at any point in the production cycle has provided the necessary requisite by which the industry can realize the desired economic advantage.

Nondestructive test methods, as applied to flaw detection, are being utilized in three different areas in the steel industry. The first is during the various stages in the production cycle for the purposes of process control. The second is as a final inspection tool to determine whether the material meets customer requirements, and the third is in preventive maintenance programs.

PRODUCTION TESTING

Nondestructive tests have the advantage of being able to be used at any point in the production cycle. Since they in no way alter or impair the usefulness of the material under test, it is possible to make the inspection an integral part of the operation itself. This philosophy of inspection is beginning to gain wider acceptance by the steel industry.

One of the steel industry's old problems is the inspection and conditioning of semi-finished bars and billets prior to further processing. Considerable time and money is being expended annually by the industry to accomplish this.

As one answer to this problem, The Timken Roller Bearing Co. in 1953 adopted one of the nondestructive tests, the magnetic particle method, for the inspection of billets for its three piercing mills. This method was integrated with a handling system that resulted in a semi-automatic unit in which both inspection and conditioning is accomplished.

Basically, the principle of magnetic particle inspection is a simple one. When a piece of steel is magnetized,

Figure 1 — Thorough inspection is made possible by the use of magnetic particle inspection prior to scarfing.

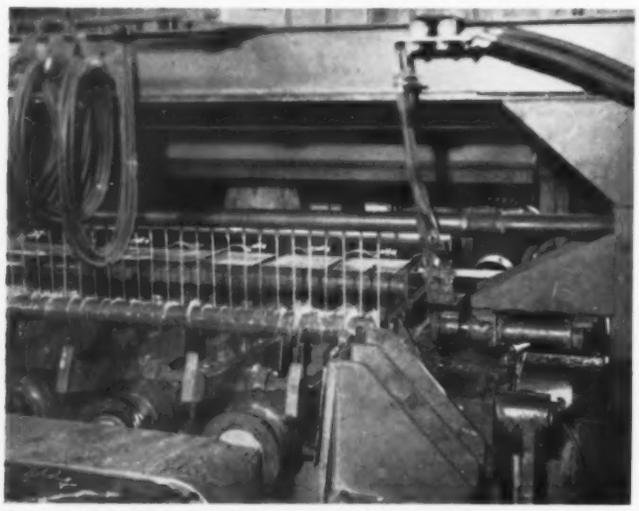


Figure 2 — The billet is magnetized and sprayed with magnetic particle solution.

Figure 3 — Magnetic flux leakage at a point of surface discontinuity is revealed by black light.

a magnetic flux leakage occurs around any surface discontinuities such as cracks or seams. When magnetic particles are sprayed over the magnetized surface, the particles aline themselves in the break, attracted by the magnetic flux leakage.

Figure 1 shows the general layout of the inspection and conditioning unit. The unit is capable of handling billets ranging in diameter from three to eight in. inclusive and in length from 4 to 15 ft inclusive. The billets are charged into the unit by means of a fork truck. After charging, the billet progresses through the billet positioner, the magnetizing and spraying station and the inspection area where the billets are marked by the inspector. After inspection the billets that require no conditioning are discharged onto the OK bed while those requiring conditioning are sent to the scarfing area and thence to the discharge bed.

Figure 2 shows a billet in the magnetization area where it is simultaneously magnetized and sprayed with the solution containing fluorescent coated magnetic particles. The billets are magnetized with circular magnetism by a heavy duty power pack having a capacity of 6000 amp.

A general view of the inspection station is shown in Figure 3. As the billet arrives at the inspection station, it comes to rest on a set of revolving rollers. These permit the inspector to slowly rotate the billet at will for inspection of the entire surface and marking of each defect. Above the rollers is a battery of ultraviolet lamps which provide "black light." The "black light" causes the defects to glow or fluoresce, making them easily detectable and the inspection more positive.

Scarfing is done with an oxyacetylene torch from a platform over the scarfing bed. There, too, the scarfer can rotate the billet at will, making the outlined defects readily accessible. After scarfing, the billet is rolled onto a discharge bed. The billets are then moved by fork truck either to the piercing mill or to the storage yard.

Prior to the installation of this unit, most tube billets were pickled, visually inspected and conditioned. Between operations, there was considerable handling. With the new inspection setup, not only was handling reduced substantially, but material costs and time and labor for pickling were eliminated entirely, since pickling of the billets is not necesssary for magnetic particle inspection. In addition, the inspection and conditioning was stepped up to an approximate rate of more than 100 billets per hr. This increased production rate is achieved with two men, instead of the seven or eight formerly used. The schedule of the inspection unit is integrated with the mill schedule. As a result, lead time between the bar mill and the piercing mill was drastically reduced.

Probably the most important advantage, from the standpoint of quality, is the more thorough inspection of steel made possible by the magnetic particle inspection. It is difficult to ascertain the value of direct benefits resulting from the higher quality of steel furnished to the piercing mills. It is certain, however, that the increased tube mill yield that has been realized, ranging from three to five per cent is partially attributed to the better inspection method.

The foregoing is a good example of an application nondestructive test method that has been integrated with the production cycle and turned to advantage

both in terms of quality and economy.

Another method of using nondestructive test methods during the production cycle is one in which the inspection is made an integral part of the operation itself. The advantage of such inspection installations is, of course, to provide superior inspection at production speeds. One example of "in-line" inspection recently adopted is the eddy curent method of inspection of steel coil that is to be used for cold heading into rollers for bearings.

Eddy current testing is an application of electronic principles wherein inspection is accomplished with minute electric currents induced by electromagnetic waves. These waves are emitted by test coils on or near the part being tested. The oscillating electromagnetic fields result in an electron flow in closed circulatory loops called eddy currents. The induced eddy currents explore the surface and subsurface of the coil and the presence of conditions that impede the flow of the eddy currents is reflected in a change of impedance of the test coil. This change in the characteristics of the test coil is sensed and measured by an electronic analyzer, which determines whether the magnitude of the defect condition responsible exceeds certain predetermined levels.

Previous to the adoption of the eddy current method of inspection, the inspection procedure for steel coil for cold heading into rollers involved visual plus magnetic particle inspection. Since the entire coil could not be examined by these methods, inspection was limited to samples taken from the ends of the coil. Therefore, to assure complete elimination of rollers made from coil that might have occasional undesirable surface defects not detected by end inspection, it was necessary to maintain numerous roller inspections during subsequent processing.

While evaluating the eddy current testing equipment and procedures, the distribution of seams in coils was investigated. The results revealed that the surface defects, while very limited in number and extent, are randomly distributed throughout the length of the coil. The random distribution of surface defects demonstrated that 100 per cent inspection of the coil surface is necessary for complete detection and elimination of surface defects in coils. The eddy current test equipment permits 100 per cent inspection.

The eddy current tester has been installed directly on the wire draw bench and inspection is made during the drawing operation. The inspection in no way interferes with the drawing operation and is conducted at the normal operating speeds of the draw bench.

Figure 4 shows an installation of the eddy current tester on a wire draw bench. The coil passes through the tester between the draw die and the take-up reel. The tester is unique in that the test coils are rotated around the wire being tested. The rotating, mounted probe contains test coils acting independently to give helical scans around the wire being drawn through the eddy current tester. The spinning probe centers on the coil enabling a complete surface inspection. The instrument electronics and operating controls are housed in the cabinet seen in Figure 4.

The presence of a defect is indicated by the output of a visual and audio reject signal. At the same time, through operation of a relay, a solenoid valve, and an air cylinder, a cutting tool shown in Figure 5 is swung against the wire being drawn. While the signal persists, the tool cuts a flat surface 0.010 to 0.020 in. deep marking the section of coil containing the surface defects.

After the eddy current inspection, the wire goes to the cold heading machine where it passes through an air gage orifice before going into the cutoff bushing. As the scored wire passes through the air gage, which is

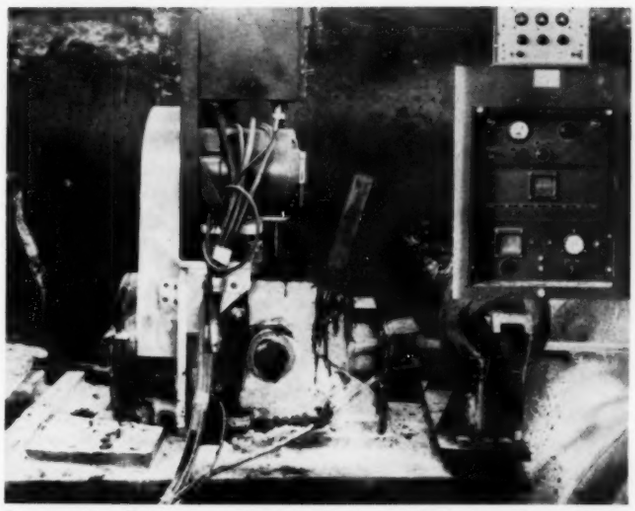


Figure 4 — Eddy current testing is combined with a drawing operation to provide full surface inspection of coiled stock.

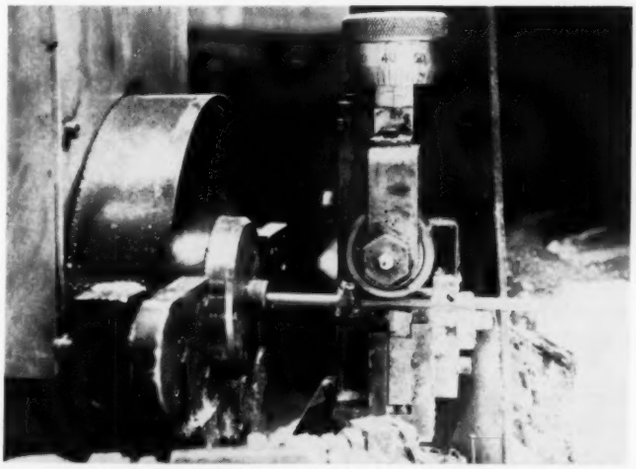


Figure 5 — Signal indication, from the eddy current tester, operates a marking tool.

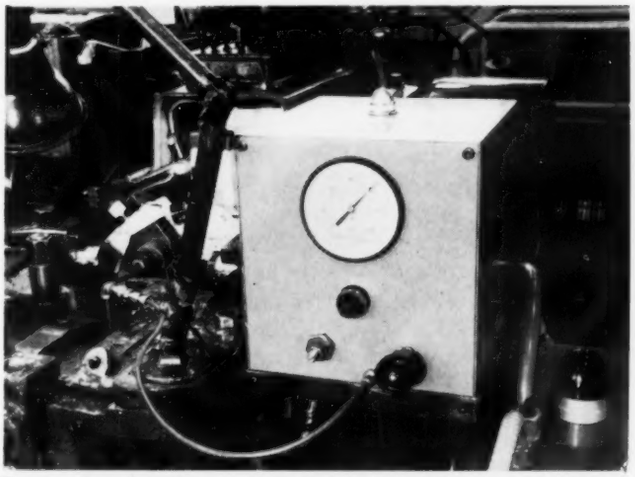


Figure 6 — An air gage controls rejection of marked sections at the header block.

connected to a pressure switch, a relay opens a reject gate in the outlet chute. Thus, a marked section of a coil is automatically sensed and the resultant pieces rejected. Figure 6 shows an air gage installation on a header machine showing the pressure control box with the air line leading to the air gage in the header block.

There is a grinding clean-up on rollers which, depending upon the roller size, establishes tolerance limits for the depth of seams in coil. There is a relationship between instrument sensitivity setting and the depth of a surface defect which makes possible descriminatory and selective testing.

FINAL PRODUCT TESTING

The second method of applying nondestructive test methods in the steel industry is during final inspection to determine whether the finished product meets customer requirements.

Ultrasonic test methods are developing into one of the more popular techniques for determining the quality of finished product. The ability of high-frequency sound to penetrate heavy sections of steel and provide an instantaneous presentation of the internal quality, together with its adaptability to test lighter sections, such as tubing, for both surface and internal discontinuities, has earned the technique growing acceptance and increasing application.

The heart of the ultrasonic system is the transducer, or search unit. This transducer contains piezo-electric material, such as quartz or lithium sulphate, which exhibits the property of being able to convert electrical impulses to mechanical vibrations and vice versa.

Ultrasonic inspection utilizes short bursts of very-high-frequency sound which is transmitted into the material to be tested by the transducer. This same transducer then becomes the receiver to pick up the echo signals which will be reflected from the back surface of the material and from any internal discontinuity. This method in which the transducer acts as both transmitter and receiver has been termed the pulse-echo method and it is the one universally used in the steel industry for flaw detection in bars and tubing. Commerical instruments are capable of utilizing frequencies of 0.5 to 25 megacycles, but the 1.0 and 2.25 megacycle frequencies are in most common use in the steel industry.

The diagrams in Figure 7 illustrate the sound paths and the resulting screen patterns obtained in the pulse-echo method of testing bars and tubing. For the inspection of solids such as blooms, billets or bars, a longitudinal wave mode is utilized and is produced by projecting the sound beam perpendicular to the surface. The ultrasound that is reflected from either a flaw or back surface returns to the transducer where it is converted into electrical impulses, amplified electronically, and displayed on an oscilloscope screen as vertical pips. The pips are spaced along the horizontal sweep line from left to right according to their time of arrival. The position of the defect indication in relation to the starting pulse locates accurately the distance of the defect from the search unit.

For the inspection of tubing, a shear wave mode of sound transmission is utilized. To obtain this wave mode, the sound is introduced into the material at an angle of approximately 45 degrees. The angle is such

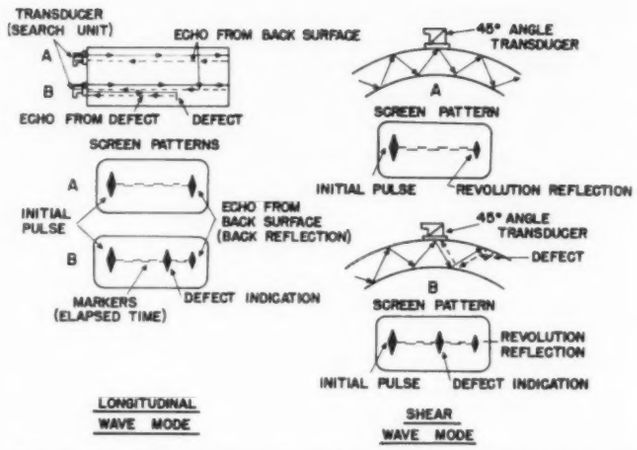


Figure 7 — Various sound paths and screen patterns are obtained in ultrasonic testing.

that the vibrations are projected around the tube by successive reflections between the surfaces until they return to the transducer or are reflected by a discontinuity, either on the surface or internal.

To permit an evaluation or interpretation of the indications obtained by ultrasonic inspection methods, appropriate calibration techniques and reference standards are necessary. The matter of calibration presents some problems because of the large number of variables possible. In order to obtain reproducible results, it is necessary to maintain uniform calibration methods. While uniform techniques can be achieved to a certain degree within a given plant, there is a definite need for uniform method of calibration which can be applied throughout the steel industry.

At present evaluation of metallurgical discontinuities are being made by attempting to stimulate the defect being sought by the use of reference standards. In the ultrasonic inspection of tubing, for example, notched standards expressed as a percentage of the normal wall thickness are being used. When testing solids, reference blocks containing drilled flat bottom holes of various sizes and lengths are being used. Another method expresses indications found as a percentage of the back surface reflection under specific conditions of frequency and transducer size. The evaluation of ultrasonic test results can be greatly aided by a correlation of the test results with those of destructive tests.

In the pulse-echo method of ultrasonic testing there are two methods by which the ultrasound is introduced into the material to be tested. The first is the contact method in which the transducer is intimately coupled to the metal surface by a thin film couplant such as oil or glycerine. The second method is the immersion method in which both the part and transducer are immersed in water and the ultrasound is transmitted through the water into the metal surface. Both methods are being used for the inspection of tubing and solids, both rounds and squares.

Figure 8 shows an ultrasonic contact unit has been designed for the production testing of up to 5-in. OD tubing. The incorporation of handling equipment has made the operation semi-automatic. As the tube enters the first drive assembly, a solenoid actuates a lever which lowers the self-alining search unit onto the tube. The speed of tube rotation is adjusted by a variable-speed drive, and the variable feed angle of the drive assemblies

control the speed of travel of the tube past the search unit. A monitoring device is included with the ultrasonic equipment and is designed to audibly signal indications that exceed the maximum permissible.

Figure 9 shows the equipment used in the immersion method of ultrasonic testing. The unit is versatile in that it can be used for testing of large tubing and both round and square blooms, billets and bars. A removable assembly is used for rotating round bars and tubing during inspection. Squares are loaded into V-shaped saddles which can be turned through 90 degrees for scanning from two adjacent sides. A semi-automatic motorized search unit positioner permits remote control of scanning with the operator placed for optimum observation of the screen presentation. Although immersion testing requires more elaborate equipment and requires the handling of each individual bar or tube, it offers the following advantages over contact testing:

1. The surface of the product to be tested is not as critical as in contact testing.
2. Scanning can be much faster, and the uniformity permits better monitoring for defect indications.
3. Crystal wear is eliminated and the newer high-resolution search units can be used to greater advantage.

Another nondestructive test device that has proved useful is an ultrasonic resonance thickness gage shown in Figure 10. This thickness gage provides a rapid and accurate measurement from one surface at points which would otherwise be inaccessible. For example, Figure 10 shows this gage being used on a stainless pressure tube at a point where surface conditioning was performed and it was necessary to know whether minumum wall had been maintained. Like the pulse-echo method previously discussed, the resonance thickness gage uses a crystal that transmits and receives high-frequency sound. The resonance method differs in that the frequency is constantly varied. Each thickness has a resonant frequency, and by continuously varying this frequency, standing waves are produced, much as a tuning fork is caused to vibrate at one tone. This condition of resonance is indicated as peaks on an oscilloscope screen and read directly by use of a scale.

For the detection of surface discontinuities in the inspection of final product, nondestructive tests that prove useful are the magnetic particle method, which was previously described, and the dye penetrant method.

Revealing surface discontinuities on nonmagnetic material such as stainless steels is effectively accomplished with the penetrant method. Several types are in use, but all depend upon the ability of a fluid of low surface tension to work its way into any minute crack which is open to the surface. The penetrant is applied, allowed sufficient time to work its way into the minute cracks, and the excess is removed. A developer is then applied which draws the penetrant remaining in the crack to the surface providing a high visual contrast with the surrounding area. Either penetrants of a vivid red color or those that fluoresce under ultraviolet light may be used to provide the contrast.

PREVENTIVE MAINTENANCE TESTING

The third method of applying nondestructive test

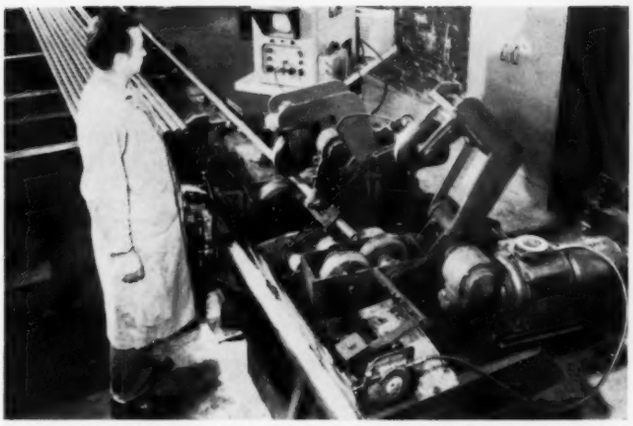


Figure 8 — Ultrasonic contact units are presently being used to test tubing of up to 5-in. OD.

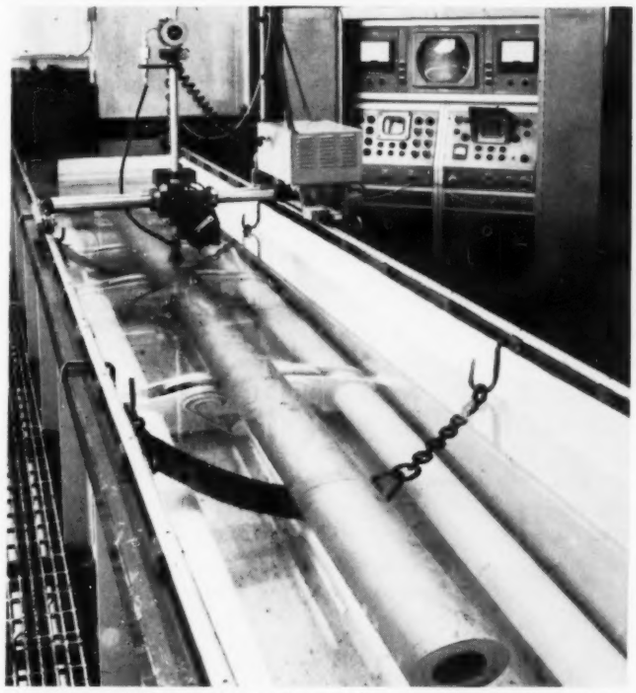


Figure 9 — Ultrasonic testing units can test various sizes and shapes at fairly fast scanning speeds.

Figure 10 — Resonant frequency testing permits thickness determination of normally inaccessible points.

methods in the steel industry is in preventive maintenance. Nondestructive test methods can be of great value to the mill operator by providing him with not only an excellent safety device in the operation of his equipment but they also can offer much to prevent or minimize production delays due to breakdown of equipment.

Detection of fatigue cracks in their early stages is the most valuable single application of the various test methods. Here the ultrasonic test rules supreme since only one end need be accessible and testing can be done without removal of the part in most cases. When the critical area is exposed, magnetic particle or dye penetrant techniques are very effective for verification purposes.

Selection of the test method and interpretation of results require collaboration between the operator and the inspector since the history of previous failures, the presence of a keyway that causes mysterious indications, or other factors are needed for intelligent evaluation. Testing of new parts before they enter service can ensure against premature failure and provides the test inspector with background upon which to base judgment in future testing after service.

EFFECTS ON THE MILL OPERATOR

There is no doubt that nondestructive test methods, applied properly, can act as an invaluable guide to the mill operator in telling him how well he is succeeding in his efforts. The fact that, in nondestructive testing, each and every piece is thoroughly examined makes it possible to determine the actual or true quality level of the product. It also provides valuable information as to the source of defects and, of greater importance to the operator, it assures that his finished product will measure up to requirements.

An in-line inspection test, in many instances, will provide a mill operator with a continuous feedback of information on the progress of his operation. This affords him an excellent opportunity not only to maintain uniform process control but to make immediate changes in his operation to correct for defective material.

The fact that nondestructive test methods can be applied during the processing of steel also makes possible the elimination of defective material as soon as it becomes defective, thus avoiding losses in both time and money that would result from applying further processing to such defective material.

The response or reaction to new inspection techniques by mill operating people will depend on a number of factors, one of which is attitude of mind toward inspection in general. Inspection must be accepted by all concerned as management's front line representative for the preservation of quality. In the past, inspection was looked upon by many as a necessary evil, but in recent years this attitude has become more healthy resulting in a spirit of closer cooperation and constructive collaboration between inspection and operating personnel.

One factor that has helped in providing a receptive atmosphere is a recognition of the industry's constant efforts to reduce the adverse ratio of production to inspection time. Large sums of money have been expended by the steel industry on new equipment and methods to speed up production. While production rates and methods have shown substantial increases, in many instances, little effort has been expended to speed up methods of inspection. Nondestructive test methods appear to have the necessary potential to supply the breakthrough toward reducing inspection time by replacing or supplementing the human eye.

Another factor that will affect the mill operator's response to nondestructive test methods is the manner in which a test method is selected and applied. The problem of selecting a suitable test method is not an easy one. There are many factors that should be considered. First and foremost, there is no nondestructive test that is universally applicable to all problems. Each method has its own limitations which make it suitable or unsuitable for a given test problem. Consequently the choice of the test method must be based on a comprehensive knowledge of the method itself. Other factors to be considered are the nature and quantity of the material to be tested, what the material is being inspected for, and the conditions under which it will be tested.

A successfully developed program must be the result of a cooperative effort between the operating, metallurgical and inspection departments. Those engaged in such a problem must be constantly in touch with the production effort. They must be aware of the mill operator's problems and constantly alert to his needs. The mill operator, himself, can play a very important role in such a cooperative effort. With the intimate knowledge of his production problems, coupled with a constructive approach, he can be of great assistance in the establishment of realistic methods of application.

By their very nature, nondestructive test methods that have been described in this article do not reveal much more than the presence, location and possibly the extent of a discontinuity in the material under examination. The establishment of standards by which to measure and classify test findings into harmless or harmful categories, however, is a problem distinct and separate from that of mere detection. Herein lies an area that still requires a considerable amount of investigation to alleviate the confusion that can arise from unrealistic or vaguely defined standards.

The design engineer requires very close scrutiny of the material he uses in critical, highly-stressed applications. This, in many instances, is both understandable and justifiable particularly if the engineer is dealing with components about which little or no service experience is known.

Production men, on the other hand, see the problem differently and at times oppose standards which to them appear too stringent. However, in deference to the mill operator, there is one basic fact that must be constantly borne in mind in establishing the degree of inspection to which his product must be subjected. That fact is the present state of the art and science of steel melting and processing which appears destined to remain with us for some years to come. Even though tremendous strides have been made by the industry during the past 20 years in satisfying the demands for improved quality, the inherent limitations and problems peculiar to the steel industry must be recognized in any standardization program. In other words, acceptance levels must be compatible with process capability as well as the metallurgical characteristics of the steel.

The assessment of this problem which involves the proper interpretation or evaluation of nondestructive test data is an extremely important matter if standards are to be established consistent with what can be done in a practical way and still be consistent with service requirements. It appears reasonable to assume, therefore, that any effective standardization program must be the result of accumulated experience of well informed people, both producers and consumers.

The steel industry, over the years, has gained a wealth of knowledge and experience through the use of standard physical and metallurgical tests and examinations. This, together with a correlation of nondestructive test data with those of destructive tests, should provide a sound basis for developing the criteria to be used in nondestructive testing.

SUMMARY

It is clearly evident that nondestructive test methods are gaining their rightful place in the steel industry. For the future, it is natural to look forward not only to continued improvements in existing types of testing equipment and techniques of using them, but also to a much broader scope of application not even envisioned at the present time.

There is no doubt that nondestructive test methods act as an essential guide to the mill operator. It is true that some problems will be presented to him with the adoption of new techniques. Solution of these problems, however, will be easier and swifter if all concerned have a clear appreciation and understanding of the objectives and incentives. The mill operator can play a big role by a constructive approach and by assisting in establishing realistic methods of application. The growth of nondestructive test methods will be supported by the steel industry where results indicate definite benefits toward achieving improved quality, increased production and reduced costs.

Discussion

PRESENTED BY

W. A. BLACK, Assistant Director of Research, Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

G. P. MICHALOS, Superintendent of Inspection, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

J. E. ATEN, JR., Nondestructive Test Engineer, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

PAUL R. RAUCH, Assistant Chief Inspector, The Youngstown Sheet and Tube Co., Youngstown, Ohio

W. A. Black: The author's incorporation of the instrument builders' laboratory developments into practical use in the steel production operations provides excellent guide lines for the rest of the industry.

Difficulties encountered in the transition from laboratory instruments to production testers have made me especially aware of the hazards. This experience leads me to ask if or how the author has avoided some of the pitfalls.

What means is used for establishing the reliability of the magnetic particle inspection? How is it established that the magnetic particle inspection locates all the defects that must be scarfed out while at the same time ignoring others that are too shallow to necessitate scarfing?

What is the average surface area inspected in an 8-hr turn by this method? A rate of 100 billets per hr was mentioned. Assuming a 7-in. round, 12 ft long, this would be 17,600 sq ft in an 8-hr turn. Is this the normal expectation?

To what extent does operator fatigue affect the reliability of the inspection?

In the use of the eddy current instrument, what product variables are registered by it and which ones are cause for rejection? Does the instrument fail to register any rejectable defects?

What is the spinning speed of the detector head and the drawing speed when testing?

How is the rotating detector head coupled electrically to the instrument or indicator?

The discussion of pulse-echo ultrasonic testing makes no reference to the fact that in some cases no back reflection can be obtained. How is this problem handled?

What is your procedure in training operators for nondestructive testing in maintenance? Maintenance work requires a greater variety of skill and greater versatility than routine product inspection.

When defect indications are obtained during the nondestructive test of a critical machine part, who decides on the action required?

G. P. Michalos: One of the limitations of magnetic particle inspection is that, while it is an excellent means for the detection of surface defects, it does not measure the depth of the defects. Indications from seams 0.010 or 0.100-in. deep will often appear identical under black light. Some work is being done with the use of radioactive material that will enable a measurement of the concentration of magnetic particles at the defect, thus relating it to the defect depth.

In the conditioning of magnetic particle inspected tube billets, all defects that are longer than two in. are removed by scarfing. It has been found from experience that defects under two in. in length are not injurious to the pierced tubing.

Our piercing mill billets range in length between 3 ft-2 in. and 15 ft and in diameter, between 2⅞ and 8 in. The average billet would be approximately 5½ in. in diameter and nine ft long. At a production rate of 800 billets in eight hr, the average surface area inspected would be approximately 10,400 sq ft.

The magnetic particle inspection operation involves the use of two men, both of whom are qualified to do both operations involved, inspection and scarfing. These two men alternate in performing these two functions so that the element of operator fatigue, particularly that of eye fatigue, is kept to a minimum. Recently a change was made in the type of magnetic powder used in the operation which it is felt further reduces eye fatigue. This new powder is comprised of plastic-coated fluorescent particles. This plastic coating prevents the loss of fluorescent material to the solution which imparted a yellowish glow to the billet surface under black light. With this new powder, the billet surface background appears dark and the defects stand out more clearly.

One of the shortcomings of eddy current instruments

when applied for the inspection of surface defects in magnetic materials has been their susceptibility to various product variables, such as changes in structure and a varying reaction to different steel analyses. With the eddy current testing equipment, many of these variables have been effectively eliminated. In our standardization program, calibration standards of different steel analyses ranging from low carbon to high carbon alloy grades were made, and the resulting calibration curves were identical in each instance.

As far as the capabilities of this equipment are concerned, once the proper calibration and inspection standards were established, the equipment has not failed to register any rejectable defects. It has been doing an excellent job.

The spinning speed of the rotating head is 1500 rpm. The drawing speed depends on the size of wire being drawn and the amount of draft being taken and is usually in the range between 150 and 180 fpm.

The manner of coupling is proprietary information of the manufacturer.

To answer the next three questions, I would like to call on John Aten, nondestructive test engineer, Steel and Tube Div. of The Timken Roller Bearing Co.

J. E. Aten, Jr.: Not much mention was made of back reflection or about interpretation or calibration of ultrasonic tests. In some tests, i.e., shear wave tube tests, there are no back reflections but there are standing reflections or signals that are a function of the tube geometry.

However, in the testing of material in which a back reflection is used and expected, we are very suspicious if we fail to obtain one. With the exception of some of the stainless sizes and grades, and under certain conditions of heavy grinding, loss of back reflection generally indicates rejectable conditions. One can almost predict the location on some stainless material where large or unfavorable grain structure related to ingot cooling pattern will reduce or cause loss of back reflection. The angle of the positioner is adjusted to obtain optimum response when testing rough ground bars and a good back reflection can be obtained in most cases.

Training operators for maintenance work is far more difficult than for any other work, and there is no set procedure. However, it is felt that any man assigned to a difficult maintenance problem must be one that has been thoroughly trained and has considerable experience in nondestructive test methods. Less experienced personnel are trained on the easier and repetitive maintenance problems first. In every instance, an attempt is made to confirm the presence or absence of defects by the use of one or more additional inspection methods. For example, to confirm ultrasonic indications, it is often possible to clean the suspected area and use magnetic particle or penetrant inspection.

When a defect indication is obtained, an attempt is made to confirm whether there is actually a defect present, and what its magnitude is. Then the people who know the history of the service of the part and the history of failures try to make an educated guess. The potential hazard of injury to people or damage to a machine must be considered.

Some service problems have been solved by redesign of the part. A simple change in welding or heat treating can remove the cause of failure.

Paul R. Rauch: Youngstown Sheet and Tube Co. has taken a similar approach: for some 11 years there have been three magnetic particle inspection stations as an integral part of the production line of the electric resistance weld pipe mill at the Brier Hill works. More recently, an automatic magnetic particle inspection equipment was installed for carbon and alloy rounds. Eddy current inspection equipment for wire and rods is presently being evaluated by trial on a bull block at the Struthers works. Other nondestructive testing equipment in use or under investigation for application to several other products. However, in all cases, the goal is to achieve dependable mill control of steel quality as an integral part of processing and at normal production rates.

The author has indicated that they are using ultrasonics for final product inspection of tubing and bars, as well as magnetic particle and dye penetrant methods. With reference to carbon and medium alloy round cornered squares and rounds, and semi-finished billets, would the author please comment on the comparative advantages and disadvantages of these various nondestructive testing methods, primarily from a surface quality standpoint? Which method is capable of showing a measure of depth of surface seam?

In magnetic particle inspection of seamless rounds, is it necessary to scarf out all indications or what criteria are used? Do you scarf all alloy steel grades?

G. P. Michalos: The application of any nondestructive test methods for control of surface quality of semi-finished product, both rounds and squares, presents quite a problem because of the handling problem and the obvious necessity for maintaining normal or adequate production rates through the inspection station. Of the three nondestructive test methods mentioned by Mr. Rauch, the magnetic particle method is the only one that is amenable to the production testing of semi-finished product. The application of this method to tube rounds as described is one example how such a test was effectively applied in the production cycle for semi-finished product.

The dye penetrant test is not the type of test that would be applied on a production basis to carbon and medium alloy semi-finished product. The test method is time consuming and requires a much better surface than would normally be associated with semi-finished product. It must be remembered that the dye penetrant test was designed primarily for use with nonmagnetic grades where the magnetic particle inspection would not be applicable.

Of the three test methods in question, the ultrasonic test method is the only one capable of defect depth measurement. Here, again, the generally rough surface of semi-finished product, as well as the adverse geometry of squares, limits the use of this method as a production tool for depth measurement. Ultrasonics is used on rounds and squares primarily as a measure of internal quality rather than for surface quality. Some experimental work has been done on depth measurement of surface defects on semi-finished product, and it offers some possibilities.

As far as defect removal is concerned, all alloy grades are scarfed with the exception of the alloy grades used in high temperature service, which are spot ground after the magnetic particle inspection. ▲

Some Concepts of Mill Bearing Lubrication Employing Oil, Plastic Grease and Oil Mist

by O. G. McCANDLESS
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. . . . adequate lubrication systems and properly trained lubrication personnel to operate and maintain the systems are necessities if the total cost of an installation is to be controlled . . . .

IT MUST be admitted that the selection of either plain bearings, using oil circulating systems, or anti-friction bearings, using a plastic grease, is a highly controversial matter with mill operating people and engineering groups, not to mention the respective manufacturers of mill equipment.

With regard to the lubricant, some thought should be devoted to: (1) how it gets from the supply source to the place intended; (2) what happens after it reaches its intended destination; and (3) selection, inspection and care of product.

Since the "total cost" is the final measure of optimum performance whatever the type of bearing, kind of lubricant or method of application, a strong look at the components of total cost would seem in order.

This discussion considers mills of the following classifications:

Blooming mills.
The 2-high temper sheet mills.
The 4-high tandem cold reduction mills.
The 4-high tandem hot strip mills.
The 4-high single-stand reversing mills.
Shape rolling mills: pipe, structural and rod.
Wheel rolling and sendzimir mills.

Most of this equipment may be found operating on one or another of the various bearing types and with varying degrees of success.

It is acknowledged that the majority of the steel producing companies have, and are now operating, one or more of the types of mills under this discussion. However, it might be interesting to produce a brand new mill to help clarify the idea of what would be liked in a mill, to make a profit. This is the reason for having one in the first place.

BUILDING A MILL

Assuming that the geographic location is approximately determined, the land securely titled and the service facilities within reach, economically speaking, at either a present factory site or a new one, two facitious procedures come to mind. The first involves a meeting of a dozen or more people, each a supposed expert in the field of constructing, operating and maintaining a rolling mill. Each is delegated with the responsibility of a solution to the problem at hand which will be called "factors of production," pertaining to this new mill. Each expert naturally has several meetings. So many meetings are planned that a "coordinator of meetings" is appointed. Finally the equipment is purchased, constructed and started in operation only to discover that many of the heartaches of previous, similar equipment have been incorporated in the new mill.

Some one has said that "everything which is developed as being outstanding will be copied." Yet, too often there are errors in copying. The second ridiculous situation is a somewhat shorter route but leads

to needless waste and expense. It is the problem of plant maintenance people being handed a new mill with little notice and little chance to train personnel, and with very sketchy instructions for trouble shooting on everything from lubrication control centers to tight coilers. This fault can often be laid at the feet of machine builders.

Pretraining and on-the-job training should be part of the responsibility of the supplier and should be insisted on if it is ever hoped to control the total cost. This most certainly applies to the new, extensive and complicated lubrication systems required on modern mill equipment.

Maintenance is concerned with every aspect from careful selection of location, area required for the operation, size and shape of the required excavation, adequate provision for drainage in locations which will take care of spillage and leakage in the underground area and the general arrangement of underground equipment with emphasis on sufficient space.

Water contamination is a serious problem in the iron and steel industry and must be reckoned with by employing the same engineering principles in every mill installation to prevent harmful fluids, used in conjunction with the operation, from reaching streams or other public water supply.

To profit from experience the existing problems which are plaguing other pieces of equipment within the plant must be considered. Provisions must be made to operate any mill with a minimum of maintenance service.

Why not face up to the obstacles encountered in the rebuilding or construction of new mills. Engineering, maintenance and operating heads should work together to meet the standards of safety, quality and production desired.

Individual opinions often preclude much factual information, which should be available and which must be considered if the mills are to be constructed and operated within a reasonable total cost.

Consider now the moving of lubricant from original package to the bearing. First, keep it clean. On many of the older mills, such as 2-high sheet mills, plain bearings are used and bearing materials such as babbitt or bronze and synthetic or a combination are employed with or without water. Here the problem is not too complicated beyond the supplying of the roll necks with adequate quantities of lubricant to do the job. While this application may seem simple, just any product will not suffice. Recent experience with 12 stands of sheet temper mills required a trial and observation of six different types of block grease to find a product which proved to be satisfactory. The grease application on this type mill is manual, with the control lying in the observed rate of consumption, temperature of necks and bearings and their condition of wear as indicated by visual inspection.

In the application of oils, something more than a supply tank, a pump and a return line is required. The supply tank must be of an adequate size, and it must be clean and readily cleanable. It must be provided with proper level and temperature indicators. The time should be past when a $250,000 oil circulating system is installed with 25¢ thermometers. The same can be said for gages and liquid level indicators. Predetermined supply pressure, temperature and volume must be maintained, and those responsible for the care and operating of the system must understand what the values mean.

It will be assumed that, normally, where plain bearings are in use, a circulating oil system is employed. Some mills are now effectively spraying roll necks in semi- or open plain bearings. However, the full flooded bearing requires systems of considerable proportions in size and extent to adequately control and service the product.

This comment is apt to cause an "I told you so," but it should be remembered that a larger roll neck can be fitted to an existing window opening by selecting a plain bearing.

Christmas trees are beautiful to behold but not on a steel rolling mill. Sight oilers carrying opaque fluids to bearings of auxiliary equipment indicate that someone had a lot of them to sell or that the engineer who checked the order specifications did not know any better. Flow and pressure indicators tell a much better story. Many bearings have been lost with sight glasses standing full of oil, but obstructed by some condition certainly not indicated by the sight feeder unless it was leaking badly enough to be obvious.

Where a flow rate within specific limits is a necessity, a flow indicator employing contact points which can be tied in with a circuit actuating signal lights or howlers should be used for good control. Visual indication of the fluid movement is usually incorporated in such equipment as an aid to the operator or inspector of the equipment.

Something should be said about lubricant consumption figures and cost of lubricant per bearing per day. One thing is clear, either fluid or plastic lubricant is expendible.

The following figures have been supplied from several mills, and are identified by number. These mills employ plain bearings and the lubricant usage is expressed in gal. Volumes are in total gal for one year's operation.

1. A 66-in. hot strip mill, with roughing stands and a scalebreaker.
   The first finishing stand uses 2400-SSU oil—8000 gal per year at 60¢ per gal.
   Three finishing stands use 1200-SSU oil—6000 gal per year at 60¢ per gal.
2. A 10-stand hot strip mill—40,000 gal per year at 60¢ per gal.
   Bearing tonnages:
   Bottom backups—3,300,000.
   Top backups—1,650,000.
3. No lubrication consumption figures available.
   Anti-friction bearing tonnage:
   Horizontal bearings—3,500,000.
4. Hot strip mill—25,000 gal per year.
5. Anti-friction bearings:
   Backup bearings (four feeds)—seven lb of grease per bearing per 24 hr.
   Work roll bearings (two feeds)—two lb of grease per bearing per 24 hr.

It is apparent that the volume requirements of these mills vary widely. No attempt is made here to introduce factors of width, speed, gage of finished coil, metallurgical types, etc., which, of course, must be taken into

account in the total cost. Some mills are using 75,000 to 100,000 gal of oil per year: lower cost oils are being used (25 to 30¢ per gal in tank car lots). Mill Nos. 1, 2 and 3 were primarily low carbon producing.

Using a 300-day operating year, mill No. 1 shows the lowest volume consumption covering 28 bearings, figuring to exactly $1.00 per bearing per day. Mill No. 6 reporting one roughing stand, a scalebreaker and five finishing stands showed a lubricant consumption of approximately seven lb per backup bearing per day using a grease at a cost of 16⅔ per lb or $1.16 per bearing per day.

In the case of mill No. 2, the cost of lubricant is $2.00 per bearing per day. For mills using the larger volumes, 75,000 gal and up of lower cost lubricants, the cost per bearing per day is 25¢. However, no mention was made of babbitting and maintenance costs. Mill No. 2 is not used to roll difficult alloys.

Each mill has its own limitations and restrictions so that specifications relating to the type of material and its finished requirements must be considered along with parting pressures, gage control, flatness and surface condition of finished product as well as tons per hr. All these specifications are important items in determining the selection of bearings and subsequently in the lubricant and its application.

Sleeve type oil bearings have been considered by many to have an infinite life as compared to anti-friction bearings having a finite life. However, costs compiled on some mills indicate that the life of both types of these bearings, in either tons rolled or hours of operation up to the point of replacement, may be somewhat closer than previously considered and that costs in some cases may converge on similar mill installations, with proper inspection and maintenance.

Where the mill equipment is especially large in physical nature, involving systems of circulating oil, coolant, hydraulics, etc., thought must be given as to the best method of delivery of the many supplies such as initial and make-up oil, filters, coolers, motors, pumps, pressure vessels and the like.

Where supply tanks are required, periodic cleaning is a must and provision to economically and effectively do this job should be well planned. Contamination in circulating or centralized systems and "delay time" to production are prominent enemies, but they can be controlled to a large degree by employing:

1. Color code piping—name plating each piece of equipment.
2. Removable heater coils or heater plates.
3. Cleanable cooler tubes.
4. Direction indicators of flow.
5. High and low level indicators.
6. Classroom instruction on equipment function.
7. Job procedure written and discussed until they are understood.
8. Lubrication charts which name the equipment, the part to be serviced, the frequency of application and the specific product to be used.

The value of periodic in-use testing of fluid lubricants should be stressed. It is not sufficient to conduct such tests and merely send a report to department heads of the results. Such reports must be taken to the personnel responsible for equipment care and proper corrective steps must be scheduled.

Substantial savings may be made by using tank car or tank truck delivery with suitable piping arrangements to convenient unloading stations. Another important advantage to bulk delivery is the decrease in the number of drums to be handled, which improves safety, reduces labor costs and releases cranes for other work.

AIRBORNE OR MIST LUBRICATION

Airborne oil as a means of lubrication through various types of air line oilers dates back many years. The primary purpose of air line oilers was, of course, to lubricate moving parts of air operated equipment and to prevent rusting or corrosion.

Airborne oil as a fine spray, mist or fog will be considered here as it may be applied to the lubrication of mill bearings. This method of applying lubricant to a mill bearing is interesting from many points of view, but chiefly as it effects our problem of total cost.

As far as rolling mill equipment is concerned, at least for the present, mist lubrication is applicable only to anti-friction bearings. This narrows the field somewhat but leaves it nonetheless attractive.

The mist lubricator was originated in Sweden. The word mist may be considered to mean either a very fine oil particle size or somewhat larger particle size in air as a spray. The selection of proper fittings control the particle size to produce the required end result. These fittings can be and often are used in combination.

In simple terms a mist lubricator is a device employing air to break oil out of its fluid state into small enough particle sizes to permit it to be carried in an air stream from supply to bearing and in a physical state acceptable to the bearing, with accurate control.

The air supply must be clean and free from moisture. Additional filtering of the air and water trapping equipment is normally required.

Both the volume of air (at pressures up to 50 psi) and the volume of oil can be accurately controlled. Since rapid changes in oil viscosity occur with temperature change, it is advisable to use controls which will maintain oil temperatures within definite limits. A suggested range would be 90 to 105 F.

In the selection of an oil for use in mist lubrication, the first factor to be considered is the viscosity characteristics of the oil. Oils ranging from 300 to 600 SSU at 100 F are generally preferred and will meet most requirements. Additive oils may be used provided they do not reduce the volume of airborne lubricant. It is possible to mist oils of 1000 SSU or more at 100 F, but lighter oils should be used if ambient temperatures are low. Cold headers and lines may result in oil dropping out of stream, plating out in lines and finally restricting expected flow.

It is not recommended that oils carrying any type of solid additive be used. Buildup within the unit will result with subsequent stoppage or faulty operation.

Most important in the application of mist lubricators is the thorough training of personnel, aiming toward a complete understanding of how mist works, how the mist unit functions and what problems may be expected in normal operation. Thermostats should be used on any installation unless room ambient temperature is closely controlled. Many units have a built-in

air inlet regulator. High and low level indicators in the oil supply tank and a complete installation of pressure switches on primary and secondary delivery lines tied into signal panels for indication of possible trouble should be insisted upon.

Important as these controls are, one thing must always be kept in mind, the pressure switches will reveal only air pressure. Oil consumption rate must be noted to determine if adequate quantities of oil are being delivered to the system.

A system employing one 300-bearing in. unit and one 500-bearing in. unit (each system is rated in relation to the number of bearing in., width times diameter, that it can properly supply with oil) is currently using 0.28 gal of oil per day per bearing at a cost of 33¢. Advantages may be listed as low comparative installation cost, smaller space requirements in mill construction, constant addition of new and uncontaminated lubricant at mill floor level, reduced fire hazards, decreased maintenance and low lubricant cost.

The chief disadvantages of mist lubrication lies in the fact that considerable training is required to develop the necessary knowledge in people responsible for mill bearing life. However, there are strong indications that the extra effort will pay off when the total cost is considered.

A number of installations involving oil mist lubrication over a wide range of applications has been observed since 1952. For the most part, the earlier applications were small anti-friction bearings on equipment where shaft speeds were in excess of 1000 rpm.

Some of this equipment operated in highly abrasive conditions. The results were most gratifying. The improved bearing life resulted primarily from the fact that the bearings were constantly pressurized, preventing abrasive material entering the bearing.

Probably the outstanding cost savings were realized on a wheel rolling mill where two pressure rolls, with roller bearings, operate horizontally taking the entire thrust of the mill rolling action. These bearings were initially designed to be lubricated with an oil circulating system. Oil costs during some months reached a figure of $300 due to inability to adequately seal these bearings under the operating conditions, with resulting heavy contamination of water and scale. Bearing failures resulted along with shaft and roll damage. Delays were frequent and costly. After the installation of mist lubricators, oil costs were reduced to less than $15 per month, excellent bearing life was obtained and very few delays were suffered. This, of course, is an extreme case. The solution lay in pressurizing the bearings, supplying fresh lubricant constantly and in keeping out the contaminants of water and scale.

A new application on a 4-high reversing cold mill has not been in operation long enough to determine bearing and roll neck life. However, two inspections of the anti-friction bearings and roll necks on the 4-high reversing mill at 25,000 and after 50,000 tons over a seven-month period show their condition to be satisfactory. A true comparison of the cost of any alternate functions or processes is possible only when all the facts are available. These factors must be compared in the same terms and under similar conditions.

The necessity of making these comparisons for cost analysis emphasizes the importance of setting up a record system consisting of all cost factors and a systematic procedure for obtaining and recording all data. The best method from a total cost point of view can be determined only when all costs are available over a long enough period of time.

Discussion

presented by

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Frank Dimit: One of the points that the author has made can stand a little emphasis, and this is the necessity of "training men." It cannot be stressed too much. There is no quicker way of breeding trouble in large bunches than turning a "green hand" loose on one of the modern lubrication systems, whether it is a centralized grease system, a circulating oil system or oil mist system. Invariably, when an improperly trained man runs into trouble he will do one of two things: nothing at all, or too much. Either choice spells disaster to the mill.

If men are to be trained in the operation and maintenance of these complicated systems, these men must have the native intelligence and mechanical aptitude to absorb this training. Too many people still picture an "oiler" or "greaser" as a character hired off the street, given a pair of work gloves and an oil can or grease gun and told to go to work. Those who still retain this idea are mistaken, and are heading for trouble.

More time and money must be expended in these training programs, and also more time and care must be spent in the proper selection of people for these jobs. Of course after a man has been selected and trained, it is desirable to hold labor turnover to a minimum. The only way of doing that is to make his pay scale commensurate with his responsibilities, and the equivalent of the top rates in the mechanical and electrical departments.

Weirton is successfully using mist lubrication on a 4-high, single-stand temper pass mill rated at 3500 fpm. It is also being used on two small electrolytic tin lines, where there had been trouble with the inboard bearings

with other lubricants contaminating the product. It is felt that this is one type of system which has not reached its full potential.

W. J. Brown: Present day industry with its high-speed, complex equipments has come to recognize the urgent need for trained maintenance personnel with particular emphasis on lubrication. All the leading steel producers have established training schools for instruction on proper lubrication and its effect on maintenance costs. United States Steel Corp. has a mobile training unit which moves from plant to plant while Armco, Bethlehem, Republic and others offer their maintenance personnel a complete training program at their individual plants. It is a well known fact that such training is beginning to pay big dividends and is reflecting a savings in the total operating costs.

The dangers of high operating costs are realized. To be competitive on a world wide basis costs must be held to a minimum. All over the world, foreign steel producers are expanding their facilities in an effort to capture foreign markets with quality steel at reduced prices. As an example, Japan is presently undergoing one of the greatest expansions ever known in the history of her steel industry. In 1946, their steel production was a mere 500,000 tons. However, by 1953 she had exceeded the peak war period production of 7½ million tons per year and it is expected that by 1962 her production will reach an all time high of 20,000,000 tons. With such production, Japan as well as other foreign steel producers will expect to expand their markets and will be offering prime products below U. S. prices. If it is hoped to continue supplying customers throughout the world at a competitive price, every means of minimizing total costs must be exploited.

Wayne G. Ritter: Lubrication of steel plant equipment has long been a function that seemed to concern only the maintenance departments. Actually it should concern all phases of manufacturing from management through operations, engineering and maintenance. It can vitally affect manufacturing costs and rate of machinery wear.

The author's concept of analyzing lubrication performance from a consideration of total cost is sound. First cost, maintenance cost, performance, lubricant consumption and other variables should be resolved into a common denominator to weigh relative advantages of bearing types, methods of application and other categories of materials and methods involved in plant lubrication. When such a total cost is developed, management is able to act more intelligently to improve practices which, without such analyses, may not have been recognized as a contributing cause of high maintenance and repair costs.

Moreover, the author has voiced a common complaint of maintenance people who are handed new mill equipment without having been consulted in the prior phases of planning and design. The suggestions certainly seem logical, and perhaps some costly errors could be avoided by bringing engineering, maintenance and operating heads into closer co-ordination, but it is doubtful if there will ever be any new mill equipment placed in a plant which completely satisfies everyone. Throughout the whole process, from conception to construction of a new mill facility, compromises are affected because of: limited funds; limited time; reciprocal trade arrangements; and personality conflicts.

Too often in the decision-making processes, people get emotionally involved and put more emphasis on "who" is involved rather than "what" is involved.

The data on lubricant consumption are interesting since these costs are not often calculated as a function of the number of bearings served by a lubrication system. They appear to be quite high for circulating oil and grease systems which bears out our general feeling that such bearings are being overlubricated in many plants today.

In circulating oil systems, huge volumes of oil are being pumped, not because the bearings require such volumes, but because of the limitations of orifice control of fluid flow from pressure headers. Likewise, bearings too often are overgreased because consumption is governed in many cases by lubrication system design rather than by bearing lubricant requirements. This is especially true of anti-friction bearings lubricated with grease. On the other hand, consumption can be minimized with proper design. For instance, a primary mill facility recently completed, cites a total grease consumption of 125 barrels of grease per year for 4400 bearings. This resolves into an average consumption of 0.044 lb of grease per 24 hr based upon 15 operating turns per week. At 16⅔¢ per lb, the grease cost is 73¢ per bearing per 24 hr. Even if consumption is doubled on these mills by reason of maintenance checks of system operation, or by curious maintenance men, the cost is but 1½¢ per day per bearing, which is well below the cost of anything else available for the lubrication of large numbers of bearings.

It is not intended to minimize the importance of mist as a means of lubrication. Even though more and more applications of mist are being made, and experience is being gained in its use, it must still be said that these installations lack the reliability of oil or grease systems. However, they are being improved in this respect, and it is believed that they have a place in specific applications in the future.

In the past few years there appears to have been a greater focusing of interest in steel plant lubrication. New developments in application equipment, development of bulk handling techniques, improved techniques in the spraying of viscous lubricants in gears and roll necks, improved system controls, development of new multi-purpose lubricants, are all indicative of a general forward movement in this important phase of equipment maintenance.

Norman Bracht: In 1953, A. E. Cichelli, lubrication engineer of Bethlehem Steel Co., said, "To what extent is the lubrication engineer called in for advice on technical problems? Is he called in before an item of equipment is to be purchased or is he called in after it is purchased? From bitter experience, lubrication engineers have become a skeptical group of individuals. They know that unless someone specifically interested in lubrication is consulted, lubrication is likely to be given secondary consideration."

The lubrication engineer is usually a member of the maintenance dept. and as such receives the same consideration that his fellow workers receive. The author has indicated that maintenance personnel are concerned with every aspect of mill design and that they should be included with engineering and operating personnel

when planning a new installation.

It is not uncommon that a lubrication engineer, through painful experience, will disagree with the mill builder's proposed system. Many things look good on paper but the conditions that will exist and under which the system must function are many times ignored.

Considerable progress has been made and will continue to be made. The many benefits to be gained are well worth the struggle.

Warren Howard: The author has pointed out one of the problems that plague bearing manufacturers, namely the cost of supplying and replacing lubricants to the bearing.

The specification of as simple a lubrication system as possible, one that is self-regulated and which requires a minimum of attention is to be desired.

One of the problems faced over the years has been the design of the inboard seal between the roll face and the bearing chock. This seal is especially important on wet mills where the danger of ingress of water and scale is as great as the danger of loss of lubricating oil. In either case there is considerable cost involved.

Probably one of the most significant advancements in the last decade has been a new inboard seal that has resulted in as much as 100 to 1 improvement in the problem of oil loss or water ingress. This seal has been on test now for two years in pilot installations and has been so successful that it is now under manufacture for over 100 new mill stands. It is felt that this seal will make a significant contribution to the reduction of oil costs with oil-film bearings.

Cliff W. Southerington: One of the most costly maintenance problems faced is contamination of the product or the roll coolant media with grease or oils from the bearings or dilution or contamination of the recirculating bearing oil with the roll coolant. Large quantities of aluminum can be rolled only to be scraped after annealing due to water, grease or lubrication oil contamination which was not detected in the rolling lubricant. Oil mist lubrication with anti-friction backup and work roll bearings have been a major contributing factor in the elimination of this source of process lubrication contamination.

In 1954, a new 33-in., 4-high aluminum finishing mill with anti-friction roll bearings and oil mist lubrication was installed. This mill was followed in 1955 with a 45-in. aluminum rundown mill and a 35-in. aluminum finishing mill both with mist lubrication and anti-friction backup and work rolls.

These mills have run five and six days a week, most of the time three shifts a day since they were installed. It has not been necessary to make a single bearing replacement or shop repair to any roll bearing on these mills. Bearing maintenance cost has been negligible, and the over-all lubrication cost has been very low.

After two years of operation of the 35-in., 4-high mill, the backup roll bearings were dismantled for an inspection and found to be in excellent condition. The original finish grinding marks were still evident in the load zones of the bearings.

In a full year of operation, one drum of 1000 SSU at 100 F, multi-purpose oil was used by the two mills. The cost of lubricating oil amounts to 0.118¢ per day per mill.

A recent listing covered over 70 nonferrous and ferrous rolling mills equipped with oil mist lubrication and anti-friction bearings since 1954. Will this new concept meet the problems which effect operation of the mills and the cost of their operation?

A. E. Cichelli: Lack of adequate attention to lubrication by some builders of equipment is a fact-of-life of long standing. Experience over many years has shown that there have been instances in which equipment builders have not necessarily offered the best or latest in "lubrication design" when engineering a new piece of equipment.

Lubrication design means not only the technique of lubrication, but also any design feature of a lubricated part that would bear on its longevity in service. No single aspect of design should overshadow the other; nor should one be considered without the other. It is true that details of design, such as lubrication, are probably not proper material for discussion in the preliminary talks with the equipment builders, and customers do not presume to go beyond very general specifications in the early stages. However, when these agreed to specifications are translated into details, the vendor's lubrication engineering in many cases is outmoded. To correct this situation, it is going to be necessary for plant engineers to prepare at least minimum lubrication standards and to insist that equipment builders give more priority to lubrication engineering.

Numerous publications have in recent months featured articles on engineered lubrication as the one certain means for simultaneously reducing the maintenance dollar and increasing machine productivity. Saved maintenance dollars are clear profit dollars! This spurt of interest in the benefits of engineered lubrication is no accident. A complete cycle has taken place over the years. Not too many years ago, equipment was designed almost exclusively for manual lubrication methods. Speeds were lower, maintenance repairs were high and production rates were comparatively low. The element of lubrication was an afterthought, and reduced productivity and unnecessarily higher maintenance costs resulted. Not until lubrication technologists displaced these initial poor designs in the field did the builders step out, belatedly incorporating some of the more modest advances. However, lubrication technology, spurred on by postwar requirements, has advanced at a faster pace and to such a point that steel mill designers would do well to redesign their equipment to capitalize on the newer developments. Any engineer, informed in the field of lubrication, is aware of advances in many areas of lubrication: materials and design of the lubricated parts themselves; the most effective lubricant for use with these parts; the means for applying the lubricant; safeguards and maintenance considerations applicable to means adopted to apply the lubricant; and maintenance methods to be applied to the lubricant itself.

As the author pointed out, the total cost involves many factors. and often, additional expenditure in lubrication is more than made up for in longer uninterrupted periods of operation. It is only when all of the above considerations are accounted for that a piece of equipment is truly designed for lubrication, and not before. ▲

The Application of Rectifiers for Processing and Auxiliary Drives

by A. S. URANO—Manager, Reversing Hot Mill Engineering
Metal Rolling Application Engineering, General Electric Co., Schenectady, N. Y.

. . . . rectifiers permit space and maintenance economies; however, the over-all economic situation must be closely studied in relation to engineering requirements before an auxiliary drive selection can be made. Current and future developments are increasing the range of application . . . .

ADVANCEMENTS in the design, protection and production of rectifier equipments has widened the field of available power supplies for adjustable-voltage auxiliary drives. In the processing line and auxiliary drive area (primarily hot mill auxiliary drives) the majority of power supply requirements range from about 25 to 500 kw. The backbone of these applications has been the motor-generator set power supply. This area has now been invaded by the rectifier equipments which include silicon semi-conductor and mercury arc rectifiers. These equipments are taking their place alongside the motor-generator set power supply as an available tool to be used to the steel customer's best advantage.

GENERAL FACTORS AFFECTING ADJUSTABLE-VOLTAGE DRIVES

In the selection of the proper power supply for a particular adjustable-voltage drive or drives, there are two basic factors which must be considered, economics and engineering. These factors are interrelated one with the other.

Economic factors—The economic factors can be briefly itemized as follows:

1. Initial costs.
2. Installation costs.
3. Operating costs.

An economic evaluation across the board for processing and auxiliary drive applications cannot be made at present, because of the relatively small field experience in this country. However, several factors are becoming evident which favor the use of silicon and mercury arc rectifier equipments for these applications strictly from an economic point of view.

One of these factors is the packaging superiority of static power supplies over a wide kw range. This allows for smaller compact power and control units installed without heavy foundations. The static equipments are usually smaller and lighter in weight than the conventional motor-generator set unit and can be installed in less accessible locations where floor space is less valuable. Examples of this could be a balcony or between building columns.

Another factor which favors the static equipment is the reduced maintenance required, and shorter periods of downtime which can mean increased production. Reliability studies of adjustable speed drives indicate that roughly 25 per cent of the electrical downtime is attributable to rotating equipment; motors, generators and exciters. With the use of silicon or mercury arc, the number of rotating machines is reduced.

As field experience increases in the use of static power supplies for processing and auxiliary drives, more data in this all important area of economics will be accumulated.

Engineering factors—Engineering materially affects the economic picture. However, more important engineering characteristics affect the ability of a power supply to perform, and to meet the application requirements of the drive system.

For purposes of discussion, engineering characteristics have been broken down into two groups. Group one primarily affects the a-c power system and drive operating costs, and includes the following:

1. Efficiency.
2. Power factor.
3. Effect of power supply on system faults.
4. Effect of power supply on system voltage drop, voltage flicker.
5. Kw, kvar and kva demands on the power system.

Since the processing line and auxiliary drive applications utilize, on a relative basis, much smaller blocks of power than the main drive power supplies, the above factors are not usually considered of prime importance in this country. Of course efficiency and power factor do affect the continuous operating costs in the steel customer's plant, but their affect is relatively small.

The second group of engineering characteristics, and the ones which are considered the key factors toward determining the suitability of the various power supplies are the following:

1. Current carrying ability.
   (a) Continuous current rating.
   (b) Peak overload current capacity.
   (c) Thermal storage capacity, thermal time constant.

(d) Rate of rise of current ability, commutating ability.

2. Voltage capabilities.
3. Reversibility.
4. Control capabilities of power supply.

None of the power supplies inherently match the motor or system drive characteristic requirements for all applications. It is necessary in many cases to modify each basic equipment to match the system drive requirements. A knowledge of the characteristics and capabilities of each power supply, along with a complete knowledge of the actual system requirements, will permit the selection on an engineering basis of the minimum electric equipment to do the job, which is therefore the most economical equipment to use for the particular application.

CHARACTERISTICS OF AVAILABLE POWER SUPPLIES

To determine the most suitable fields of applications for the various power supplies, it is in order to compare these equipments in the light of the above characteristics.

Motor-generator set power supply—The motor-generator set is the basic power supply which has been used for many years in the processing and auxiliary drive area. It most closely matches all of the d-c motor inherent characteristics from a current and voltage standpoint. However, from a practical standpoint the generator's ability to commutate high rates of current rise may be limiting. The standard adjustable-voltage generator has a commutating ability in the order of 10 to 12 per unit current per sec. For some applications rates of rise of current in the order of 30 to 40 per unit per sec are required. This can mean a nonstandard generator of increased capacity which adversely affects the economic picture.

The motor-generator set again does have some practical limitations from the standpoint of excitation power levels (gain) and speed of response. The power levels of excitation for the generator are considerably higher than the power level requirements for the static power supplies. In addition where high rates of forcing are required to provide fast speeds of response, these excitation requirements increase considerably. Again, such requirements may adversely affect the economic picture.

Silicon semi-conductor power supply—The heart of the semi-conductor rectifier power supply being used today is the silicon diode. It can be termed a unidirectional device which allows current to pass in one direction and prevents current from flowing in the opposite direction. The straight diode type silicon cell also has no ability to block current in the forward direction.

Silicon diodes have been manufactured in current ratings up to several hundred amp. Therefore, it is necessary to utilize silicon diodes in parallel to provide the needed kw for the larger processing and auxiliary drive applications.

From a therma! standpoint the silicon diode has a very low time constant, in the order of fractions of a sec, which necessitates the use of high speed protection against short circuit currents. In order, therefore, to

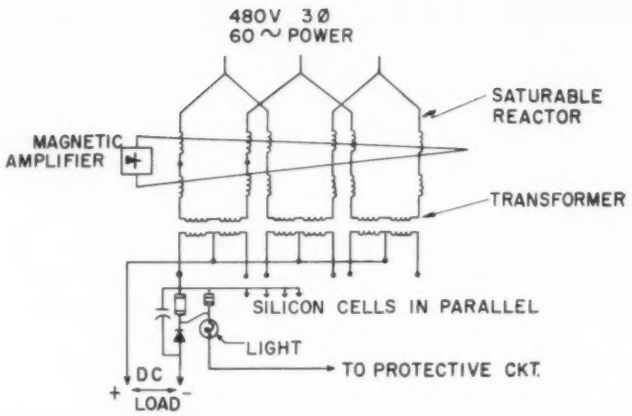


Figure 1 — Saturable reactors are used here to limit current and protect the diodes.

provide sufficient capacity for frequently repeated one-min overloads, the number of silicon diodes in parallel must be increased so that the continuous rating of the diode is not exceeded.

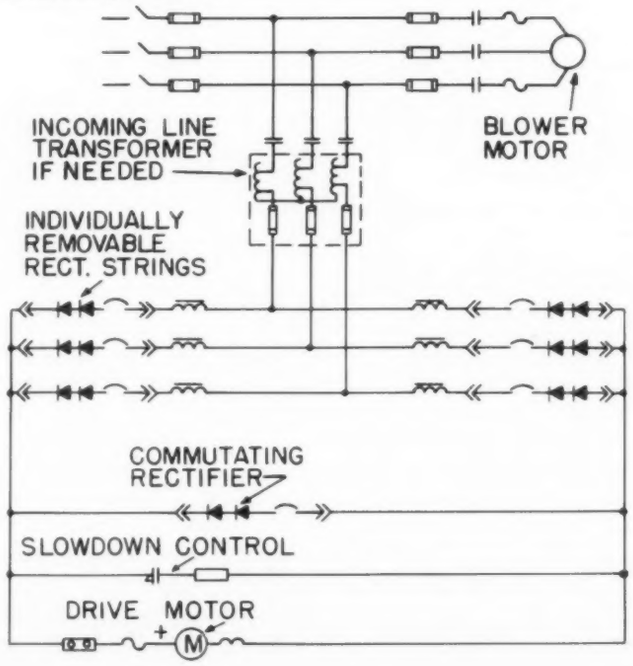
The silicon diode is also subject to thermal stresses which may cause fatigue failure. This also requires derating of the silicon diode and thus an increased number of cells used in parallel for such applications.

The silicon diode has very specific inverse voltage ratings which must not be exceeded even for microseconds. Built-in protection against surge voltage is required and is being provided as part of the rectifier equipment.

At present, where applications require operating voltages in excess of 250 volts, silicon diodes connected in series are required.

A fundamental limitation of the silicon power supply is its inability to regenerate power. Where accurately controlled regeneration is required, the silicon rectifier equipment is not suitable. Regenerative braking can be accomplished in the drive system by

Figure 2 — A circuit similar to the magnetic amplifier regulator can be produced using silicon diodes and self-saturating reactors.



dynamic braking, normal coasting of the motor or by a slowdown regulator.

When using silicon semi-conductor power supplies, there are various methods of providing voltage control from zero to 100 per cent voltage which include the use of induction voltage regulators ahead of the silicon diodes, saturable reactors and self-saturating reactors (magnetic amplifier). The induction voltage regulator method of voltage control is relatively slow; therefore, its use is questionable for processing and auxiliary drives where fairly fast changes in voltage over a wide range are needed. When the d-c system is subject to high faults, full range saturable reactors are often used for voltage control, since they add current limiting action to the circuit and help prevent damage to the diodes without calling high-speed protective circuits into action. Figure 1 shows a simplified sketch of a semi-conductor power supply utilizing the saturable reactor voltage control. A regulating system working into a saturable reactor will have good response and will permit accurate control of the process.

The type of voltage control now being applied most extensively to adjustable-voltage motor drives is shown in Figure 2. Control of the d-c output voltage is accomplished by self-saturating reactors which together with the silicon diodes form a magnetic amplifier similar in most respects to the familiar magnetic amplifier regulator used throughout industry today.

SILICON SEMI-CONDUCTOR POWER SUPPLY APPLICATIONS

The above characteristics indicate that the silicon rectifier power supplies will be most suitable and economical in applications where the following system requirements are evident:

1. Operation at constant currents up to rated current for long periods of time.
2. Operation of drive system in the motoring quadrant only.
3. Stopping of drive system or systems by dynamic braking is considered satisfactory.
4. Controlled stopping is required and the following combination of conditions exist:
   (a) Slow speed drive, in the order of 200 to 250 fpm maximum.
   (b) Low drive inertias.
   (c) Time of deceleration adjustable so that no regeneration is required, or regenerative current requirement of individual drive system is small compared to forward motoring current requirement.

The applications must be looked at with care where the following system requirements are specified:

1. Rapid fluctuations in current within continuous rating of power supply due to constantly changing load requirements during operation.
2. Frequently repeated overload requirements including impact loads, repetitive cycling requirements, etc.
3. Controlled stopping is required and several of the following conditions exist:
   (a) High speed line.
   (b) Fast controlled deceleration required.
   (c) High drive inertias.

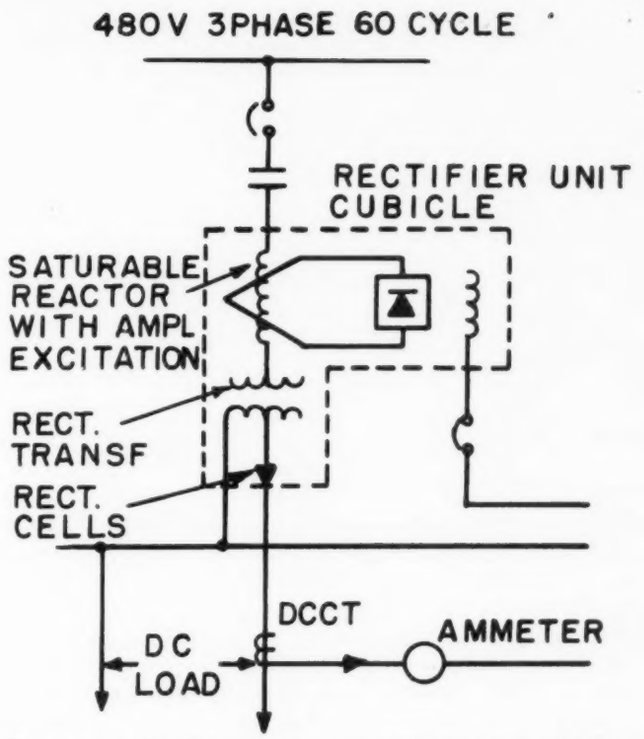


Figure 3 — Highly accurate current control is provided in the low voltage-high current power supply shown.

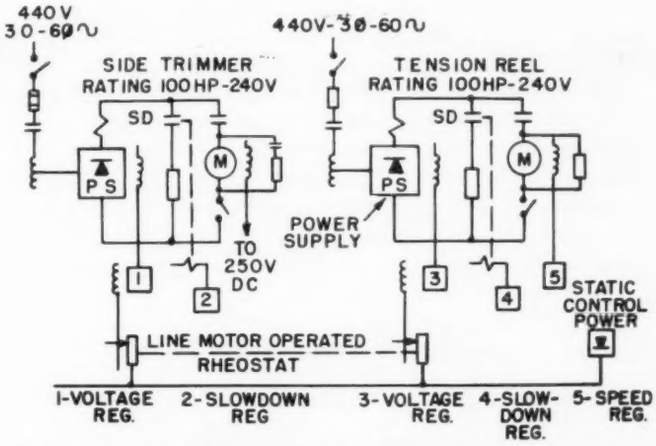
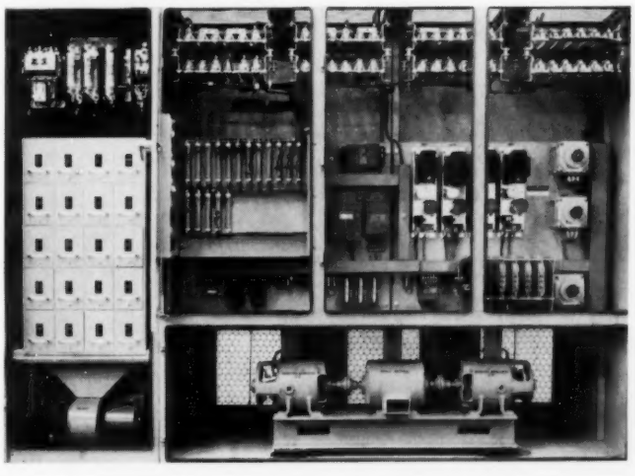


Figure 4 — This slow speed coil build-up line system uses slowdown regulators for automatic dynamic braking.

Figure 5 — This 60-hp static power supply has the silicon diodes in removable trays.



(d) Little allowable variation in strip tension.
(e) Regenerative braking current requirements are high.

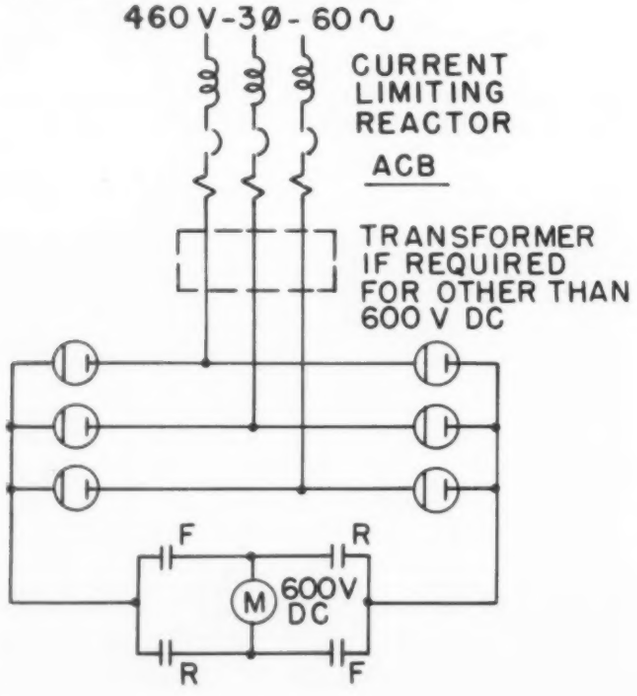
Typical applications which have been applied and are being proposed utilizing the silicon power supplies are as follows:

1. Low voltage, high current power supplies for electrolytic tin plating, cleaning and pickling.
2. Adjustable-voltage motor drive applications in sintering plants in ranges of ½ to 60 hp for table drives, swing spout drives, apron feeders, sinter cooler drives and sinter machine pallet conveyor drives.
3. Small single zone processing lines such as annealing, pickling, recoiling, etc., where top speed of line is in order of 150 to 250 fpm.

An example of low voltage-high current power supply is shown in Figure 3. These equipments have been supplied in ranges of 8 to 30 volts direct current and in blocks of d-c currents ranging up to 10,000 amp. The power supply consists of a saturable reactor with magnetic amplifier excitation, rectifier transformer, silicon diodes in water-cooled arrangement and necessary protective and indicating devices. In conjunction with a static regulating control system, highly accurate current regulation can be provided at better than ½ per cent accuracy at full load current.

A typical one-line sketch of a small slow speed, heavy gage coil conditioning line is depicted in Figure 4. This line accelerates and decelerates slowly. Maximum running speed is 200 fpm. The line is driven by two 100-hp adjustable-voltage drives, one for the side trimmer and one for the tension reel. A silicon semi-conductor rectifier utilizing the magnetic amplifier principle is used for each drive. Both static power supplies are under the control of a single motorized rheostat with one dial section for each rectifier. Therefore, the line

Figure 6 — This mercury arc rectifier tube arrangement utilizes an armature reversing switch.



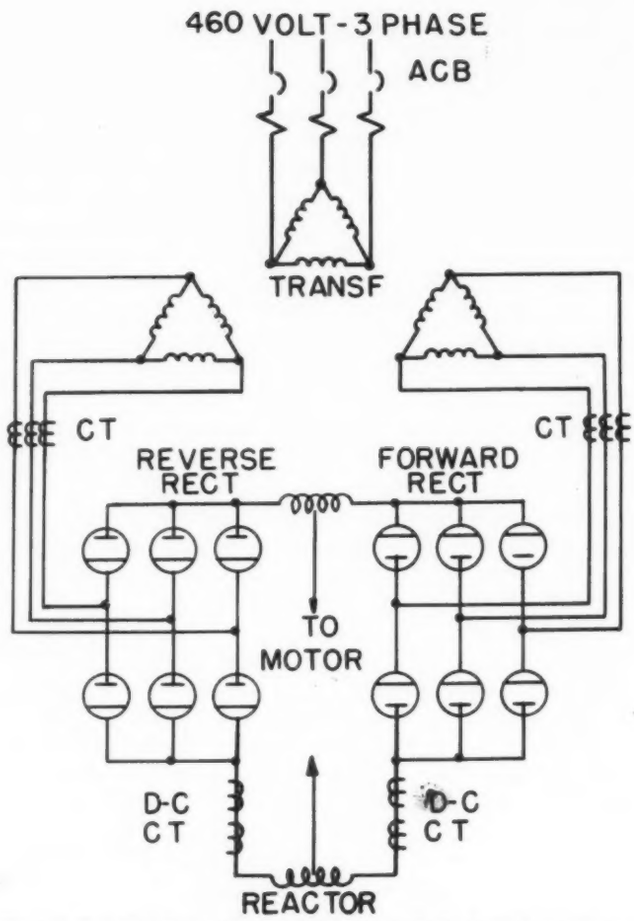


Figure 7 — Dual rectifier circuits supply 2-direction power in a continuous action; no delay occurs during reversal.

accelerates smoothly and in synchronization throughout its speed range. Slowdown regulators providing automatic dynamic braking are supplied in case regenerative braking should be required. During deceleration, if the drive cemf becomes larger than the voltage reference for the desired speed position, a magnetic amplifier picks up a relay to apply a slowdown resistor across the d-c bus. The slowdown resistor accepts pumpback power until the cemf decreases to the desired value, at which time the slowdown resistor is removed from the bus.

Figure 5 shows a typical static power supply for a 60-hp adjustable speed motor drive with silicon diodes in removable drawout trays, booster motor-generator set and d-c control equipment. The saturable reactors, a-c control and additional d-c control are mounted in the rear of the unit. These packaged units are pretested and adjusted at the factory.

MERCURY ARC RECTIFIER POWER SUPPLY

The big brother of the silicon rectifier, the mercury arc ignitron rectifier is also a unidirectional device which has the ability to allow current flow in the forward direction and block reverse current flow under normal operating conditions. Interruption of current flow through the rectifier tube is accomplished by applying zero or inverse voltage across the tube. However, the ignitron rectifier can prevent current flow in the normal direction from starting again until it is desired.

Current capabilities—Rectifiers are rated 200 per cent load for one min occasionally repeated, similar to generators. They are also capable of carrying high momentary overloads for short times on an emergency basis, and are not damaged by d-c short circuit currents when protected by standard semi-high speed d-c switchgear.

The mercury arc rectifier has one definite advantage over the generator and that is in its ability to commutate extremely high rates of current rise. The commutating ability of the power supply no longer needs to be limiting. Severe applications where extremely high changes in current in per unit per sec are required to meet short cycling times can be met easily by the use of the mercury arc rectifier.

Voltage capabilities—Ignitron mercury arc rectifier equipments utilizing small sealed tube rectifiers are available in ratings up to 500 kw at 250-volts d-c and up to 1000 kw at 600-volts d-c. Therefore, this equipment is not limiting.

Reversibility—Basically the mercury arc rectifier cannot accept pumpback current. However, because of its ability to block forward current and its ability to operate as an inverter, rectifiers can be utilized with the proper associated electric equipment for reversing operation. This makes the mercury arc rectifier equipment comparable to the motor-generator set for reversing operation.

The key to rectifier reversibility is inverter operation which means controlling the rectifier and its load in such a way that d-c power supplied by the load is changed into a-c power and pumped back into the a-c system. This provides controlled regenerative braking of the motor in a manner analogous to the regenerative braking obtained by a motor pumping back into a generator. The major difference is that current can flow in only one direction in a rectifier so that power reversal has to be accomplished by reversing the voltage.

At present the two most common methods of obtaining voltage reversal for inverter operation are as follows:

1. Use of one rectifier equipment and reverse the motor armature connection.
2. Use of two complete rectifiers supplying currents in opposite directions.

Figure 6 shows simplified sketch of a 6-phase double way rectifier with armature reversing switch and motor drive. The reversal of motor armature connections is obtained by a heavy duty armature reversing switch capable of extremely fast and frequent operation. Switching is synchronized such that operation occurs at zero current. The use of an armature reversing switch has one drawback, dead time during switch reversal, where the motor drive is uncontrolled. This dead time is in the order of 200 milliseconds.

The use of two complete rectifiers supplying currents in the opposite directions is accomplished by utilizing two sets of rectifier tubes and control, with one rectifier transformer, or two rectifier transformers depending upon the application. Figure 7 shows a simplified sketch of two double way, 6-phase rectifiers in back-to-back connection. Each rectifier supplies power for operation in one direction and acts as an inverter to absorb regenerated power during reversal or slowdown from the other direction. This scheme provides smooth continuous operation from motoring to regenerating with no delays during reversal.

Please note that Figures 6 and 7 are only two of the practical circuit arrangements that can be used with the mercury arc rectifier tubes. The actual circuits will depend upon the available a-c power source voltage, d-c power output voltage requirements, duty cycles, number of power supplies used in process line or auxiliary drives and operating requirements.

Control capabilities—A rectifier with an electronic or the new silicon controlled rectifier firing circuit basically responds with almost no time delay to a signal

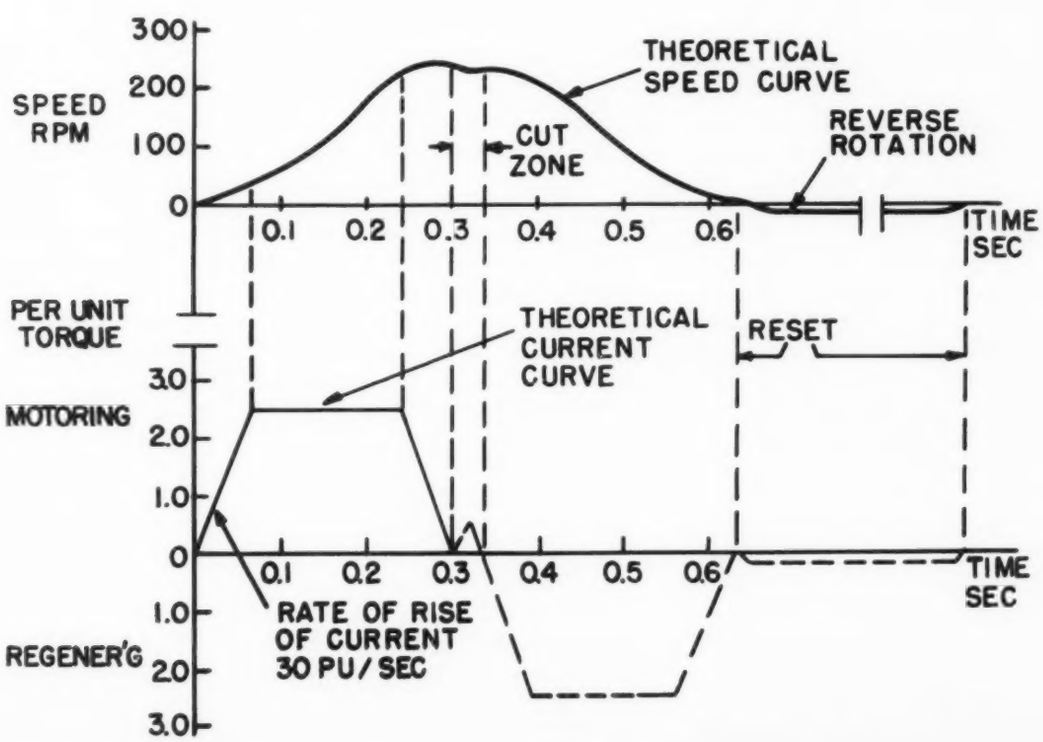


Figure 8 — Mercury arc rectifiers have practically instantaneous response to any voltage change.

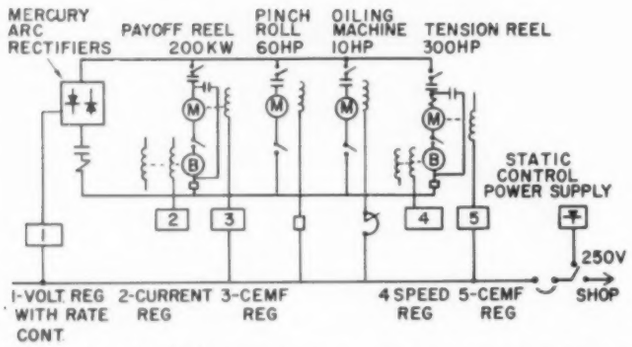


Figure 9 — A 150-kw rectifier is combined with a 50-kw rectifier, which operates in the reverse direction, as an economic consideration in system design.

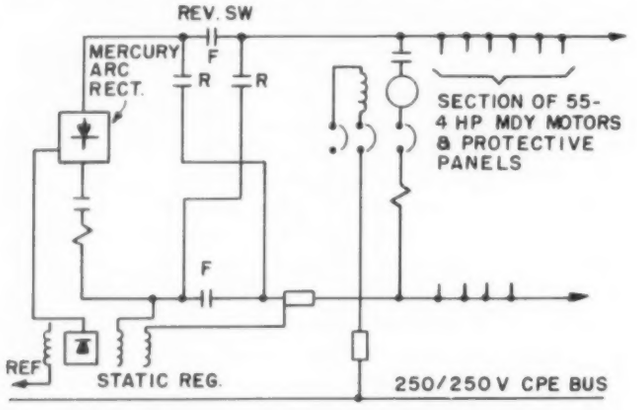


Figure 10 — Hot strip mill runout table motors can be provided with this type armature and field circuits.

calling for a change in the rectifier output voltage. This short time constant, and the extremely low power level input required to control the rectifier allows extreme flexibility in voltage control, high speed of response and high accuracy in performance.

MERCURY ARC RECTIFIERS APPLICATIONS

Based upon the above characteristics, it is possible to provide suitable mercury arc rectifier equipments for all applications now being powered by motor-generator sets.

In general, the selection of mercury arc rectifiers will be one of economics. Therefore, it is important to know the application requirements so that only that rectifier equipment needed to do the job will be supplied and not necessarily all modifications to meet the generator or motor inherent characteristics. If reversing is not required, why supply a reverse rectifier or armature reversing switch? If only small amounts of regenerative power are required, why provide a full rated mercury arc power supply in both directions? The mercury arc rectifier with its flexibility in circuit arrangements may mean the most economical application if a good engineering evaluation is made.

Specific applications for mercury arc rectifiers have been built or are being proposed in the following areas:

1. Critical, high performance drives: back-to-back mercury arc rectifiers have been applied to several crop and cobble shears, and one flying hot saw. The high commutating ability and instantaneous response to a voltage change has made the mercury arc rectifier a natural for these applications. The critical duty cycle requirements for a crop and cobble shear are illustrated in Figure 8. The complete cycle of acceleration from rest to running speed, cut and deceleration to rest must be accomplished in approximately 0.6 sec. The rate of current rise required for the short cycle times was calculated at approximately 30 per unit per sec.

2. Processing line applications: in the processing line area, a back-to-back mercury arc power supply is being applied to a 1000 fpm recoil line. A simplified schematic shown in Figure 9 points out the features of this application. Back-to-back rectifier equipments are utilized to permit smooth transition from motoring to regeneration during regulating and decelerating operation. Accurate strip tension is maintained throughout the operating range by a static current regulator on the pay-off reel. A knowledge of the drives torque requirements in both the motoring and regenerating quadrants permits the selection of a full size rectifier (150 kw) in the forward direction and a reduced size rectifier (50 kw) in the reverse direction.

3. Mill auxiliary drive application: in the hot mill auxiliary drive area, mercury arc rectifier power supplies utilizing the back-to-back rectifier arrangement are being built for a reversing hot mill table drives, screwdowns and sideguards. Rectifier kw ratings range from 35 to 200 kw. Either the single rectifier with armature reversing switch or the dual reversing rectifiers can be applied for the majority of hot mill auxiliary drives. For example, Figure 10 illustrates a 6-phase double way mercury arc rectifier with armature reversing switch as proposed for a section of hot strip mill runout tables.

The exception to the use of the single rectifier and armature reversing switch, of course, is in short cycling operations such as shears. In addition some screwdowns operating in automatic gage control systems or automatic programming control systems may not be able to tolerate the armature switch delay time.

Nonreversing mercury arc rectifiers are being built for a universal finishing stand mill tables, hot saw approach and runout tables. Rectifier kw ratings for these applications range from 70 to 125 kw. In addition mercury arc power supplies have been applied, and are now being built for reversing mill main drive motor field excitation service.

THE FUTURE OF SILICON AND MERCURY ARC RECTIFIERS

The future for both silicon and mercury arc is good, as gains are made in both field experience and production techniques with these static equipments.

As experience is gained with the new silicon controlled rectifier, it will ultimately replace the present silicon diode in adjustable-voltage motor drives and will permit this equipment to be used for reversing applications economically.

The mercury arc rectifier, as evaluated in drives now in service, may gradually replace motor-generator sets if economics permit in most critical applications, such as crop and cobble shears, cooling bed cut-to-length shears, flying hot saws, etc.

In the final analysis, except for critical applications where one particular power supply stands alone, the selection of the d-c conversion equipment will be on an economic basis as it affects the particular application and steel customer in question. ▲

Waste Heat Boiler Applications at Inland Steel Co.

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. . . . steam supplied by waste heat boilers can supplement normal boilerhouse operation, and with auxiliary firing they can provide an extra steam supply during periods of peak loading or when waste heat is not available . . . .

THE tremendous quantity of heat required in steelmaking processes is evident to those working in the mills and also to any who have seen the red glow in the sky at night or the white heat of the metal as it pours from a furnace. Much of the heat from the various steelmaking processes leaves the furnace, or soaking pit, as flue gas at temperatures that make it economically feasible to recover the heat for preheating combustion air or generating steam. This article will deal only with the recovery of waste heat with boilers to generate steam.

Inland's first application to recover waste heat was made over 50 years ago when the No. 1 open hearth shop was built. Two waste heat boilers were installed at that time and there are now 55 waste heat boilers operated at Inland. There are five waste heat boilerhouses: three located in the open hearth shops, and two recovering heat from soaking pits. The combined installed capacity of these 55 units is 1,070,000 lb of steam per hr.

Steam generated by the five waste heat boilerhouses feeds into the plant steam system and is used for process or heating. All of these boilerhouses, with one exception, operate at 200 psi. The exception is the No. 3 open hearth boilerhouse which operates at 250 psi. Any steam not used within No. 3 open hearth feeds into the 200-psi plant steam system. At Inland, as well as at many other steel mills, expansion and increased use of space heating has taxed steam generating capacities. To cope with the problem of supplying more steam with existing equipment auxiliary burners were added to an existing installation, and in two recent installations the auxiliary burners were included with the boilers. With auxiliary burners the maximum capacity of the boilers can be utilized and a steady dependable steam supply is realized regardless of the variations in waste heat from the furnaces.

During normal mill operations over 500,000,000 lb of steam per month are generated by the waste heat boilers without any auxiliary fuel firing. If necessary, the auxiliary burners can be used to increase this amount by approximately 25 per cent. The use of auxiliary burners is dependent on the fuels available and how much steam is being put into the plant system from other boilerhouses. A gas-fired boilerhouse with a capacity of 300,000 lb per hr and a limited supply of steam from two other boilerhouses, that produce steam primarily for power generation and blast furnace blowers, add steam to the plant system.

The 55 waste heat units that comprise the five waste heat boilerhouses are divided into 20 fire-tube boilers and 35 water-tube boilers. Both classifications of boilers are used in open hearth waste heat service and also to recover heat from soaking pits. In the original waste heat boilerhouse at No. 1 open hearth, water-tube boilers of the sectional header cross drum type were installed. The use of 4-in. inclined straight tubes with the 3-pass construction has proved to be an efficient design for open hearth waste heat service. Dependability of this boiler design is emphasized by the fact that there are 26 boilers of this type in open hearth waste heat service and ten of the 26 have been in service since 1916. Rated capacities of the sectional header boilers range from 15,000 to 25,000 lb of steam per hr.

When No. 3 open hearth was expanded in 1958 by adding three more furnaces, the waste heat boilers to be installed were given very careful consideration. The boiler selected was a straight through, single-pass, horizontal 2-drum bent-tube boiler with rated capacity of 56,000 lb of steam per hr. The third type of water-tube boiler used was designed for recovering waste heat from soaking pits. As auxiliary firing with either gas or oil was a prime consideration, a 2-drum bent-tube water-walled boiler was selected for this service.

Fire-tube boilers are used in No. 2 open hearth on 14 of the 24 furnaces. This type of boiler was used because the low headroom requirement permitted them to be placed in the basement rather than on the furnace floor level where space was at a premium. Six more fire-tube boilers are used on soaking pit service to bring the total of fire-tube boilers in service to 20. The 14 fire-tube boilers on open hearth furnaces and five of the six on soaking pits are rated at 13,000 lb of steam per hr. The sixth boiler on soaking pits is a much larger boiler with 10,200 sq ft of heating surface rated at 45,000 lb of steam per hr. This boiler recovers heat from a battery

of six pits while the smaller boilers are each connected to a battery consisting of three pits.

The types of boilers used at Inland have been described briefly and a discussion will follow on how the different types of boilers compare under operating conditions.

CLEANING BOILER SURFACES

The cleaning of boiler surfaces, both fire side and water side, requires considerable time and is of prime importance when selecting a boiler for waste heat service. The amount of cleaning on water-side surfaces is dependent on the feedwater conditions and treatment results. Four of the five waste heat boilerhouses use various forms of internal treatment and the most recent waste heat installation at No. 4 slabbing mill has a hot-lime, zeolite water treatment system. No. 1 open hearth and No. 2 open hearth boilers use a treatment compound in a ball briquette form that is fed continuously to the suction side of the boiler feedwater pump by means of a by-pass pot feeder. In No. 1 open hearth, 12 sectional header boilers are fed treatment compound through one pot feeder. Distribution of the compound at No. 1 open hearth is good, but in the case of No. 2 open hearth where there are 24 boilers, the pot feeder is used to put the compound into the suction of the pump supplying water to the feedwater heater. By putting the compound into the heater tank proper mixing is insured and there is no difficulty with distribution. The treatment compound used in No. 3 blooming mill on the six fire-tube boilers is received in drums and has the consistency of a heavy grease. This compound is dissolved to form a solution and then fed to the suction side of the boiler feedwater pump by means of a small centrifugal chemical pump. Feed is not continuous and control is maintained by operating the chemical pump on a timer that can be set to feed according to steam load.

Three boilerhouses: No. 1 open hearth, No. 2 open hearth and No. 3 blooming mill all operate with the same feedwater conditions and treatment results are very similar. Deaerating heaters are not used and feedwater temperature is maintained from 120 to 130 F. At these temperatures corrosion and scale of preboiler piping is not a problem so the small amount of organic contained in the compounds used is sufficient to keep any deposits from forming in lines or valves. Each boiler in these three boilerhouses has continuous blowdown to control boiler concentrations. The continuous blowdown water from each boiler is directed to a heat exchanger, one on each boiler, and feedwater entering the boiler passes through the heat exchanger recovering heat from the blowdown.

The No. 3 open hearth makes use of internal treatment; however, it differs from the other internal treatment systems in that many refinements have been made. Deaerating heaters maintain feedwater at a constant 220 F which makes it necessary to add chemicals to prevent corrosion and scaling. Chemical proportioning pumps are used to add the chemical solutions to the feedwater. Sodium sulphite is fed to the storage section of the deaerating heaters to scavenge any oxygen remaining after deaeration. An organic material is fed continuously into raw water before it enters the continuous blowdown heat exchanger or the deaerating heaters to prevent scaling. The main treatment compound is fed to the discharge side of the boiler feedwater pumps by a proportioning pump that has an adjustable stroke and is operated on a timing cycle. Water-side results are very similar with the various internal treatments used; however, the more exact control maintained with the proportioning pumps at No. 3 open hearth does result in cleaner boilers. In all boilerhouses operating crews keep a check on treatment by running alkalinity and chlorides to determine proper setting for compound feed and continuous blowdown. Chemists trained in water treatment techniques check water samples daily to insure proper feedwater and boiler water conditioning.

The water-tube boilers that use internal treatment have all tubes turbined once each year when the boiler is prepared for annual inspection. Sectional header boilers are drilled from the hot end so all handhole caps on this end are removed each time the boiler is washed. Cold end caps are removed every second year to clean and give the headers a thorough inspection. With proper intermittent blowdown during operation very little sludge accumulates in the tubes or headers of this type boiler. It has been found that a 10-sec blow followed by a brief waiting period and then another 10-sec blow is very effective in keeping sludge deposits to a minimum.

Cleaning the water side of a fire-tube boiler cannot be done as thoroughly as on a water-tube boiler where all parts are accessible to either hand or mechanical cleaning. The most effective method of removing sludge or scale deposits from a fire-tube boiler is to dry the boiler thoroughly and run knockers through the tubes. This method of cleaning is used once each year, and every fifth year the boilers are acid washed to remove any deposits from the tubes, tube sheets and the boiler shell.

The No. 4 slabbing mill waste heat boilers using water treated in a hot-lime, zeolite system have been in service for two years and have presented no cleaning problems. These boilers will probably be acid washed about once every three years. Externally treated water was necessary for these boilers as they were installed with the intent of generating steam by firing auxiliary fuels in conjunction with waste heat from the pits. Boilers have a maximum rating of 35,000 lb per hr and have been operated at this rating for days at a time with auxiliary firing producing 50 per cent of this output. The high rate of heat release and a boiler design with small bent tubes made it imperative that good quality feedwater be used.

In summing up the cleaning of the water side of boilers, the most desirable solution would be to have treated water from an external system of such quality that sludge and scale would not be a problem. However, economics favor the use of internal treatment where operating conditions and design of equipment permit its use. Inland has studied the advantages of time saved and thorough cleaning that can be realized with acid cleaning and will soon have equipment so that the boilers can be acid cleaned.

Cleaning the fire side of boilers in waste heat service is important, not only to efficient heat recovery, but in maintaining open boiler passages for adequate drafting of furnaces. As open hearth productivity increases, it has been necessary to revise flue-blowing techniques

and in some cases to alter the design of the original equipment. As an example of altering equipment, the superheaters on all 24 boilers in No. 2 open hearth have been changed from the original design. Ten of the boilers have superheaters that are located between the basement floor and the furnace floor levels and housed in a refractory lined steel casing. Elements are in the shape of an inverted V and are covered with finned castings to increase the heat transfer area. The close spacing of the elements and the finned castings formed a natural trap to hold the dirt in the flue gases. Hand lancing through an access door could only be done with the boiler out of service. This problem was corrected by shortening every other element which left larger openings for the flue gases and the hand lancing was replaced by a retractable soot blower. The large draft loss was eliminated, and the superheater can now be blown with the boiler in service. On the remaining 14 boilers the superheater elements are suspended in the tunnel that carries the flue gases to the boiler. Close tube spacing on the original superheaters created a dirt catcher which was difficult to keep clean. New superheaters with wider spacing between elements were installed, and plugging is no longer a problem.

The 26 sectional header boilers in open hearth service present the most difficult external cleaning problem. Boilers are blown once each day by flue blowers using hand lances. Blowing is done through the small lance holes located in the center of each pass between every row of tubes. Air is the normal blowing medium, but steam is used if deposits are stubborn and cannot be moved with air. Air is preferred because of safety, and it is much easier for a flue blower to handle an air lance. Hand lancing is the only means of blowing the sectional header boilers as the close tube spacing and tube arrangement make it impossible to adapt any means of mechanical soot blowers to do the job. Figure 1 shows a flue blower using an air lance in the center pass on a sectional header boiler at No. 3 open hearth. The platform from which the flue blower works can be raised or lowered by means of a hand-operated chain hoist.

When three boilers were added to No. 3 open hearth in 1958, the method of keeping the boiler passage clean was considered carefully before a boiler was selected. Figure 2 shows how the horizontal 2-drum boiler selected was fitted with retractable soot blowers. There are ten retractable soot blowers on each boiler and they do an excellent job of keeping the boiler pass free of any dirt accumulations. Boilers are kept clean by blowing the two soot blowers twice each day and the other eight once each day.

Fire-tube boilers on open hearth service are hand lanced once each day using dry superheated steam at 200 psi. This type of blowing is very effective and will usually keep tubes clear for the entire campaign of the furnace. When the boiler is down during furnace rebuild, tubes are turbined to remove any deposits. Fire-tube boilers on soaking pits do not require any blowing and are cleaned on the fire side, if necessary, when the boiler is taken out of service for annual inspection.

Figure 3 illustrates the rotary hand-operated soot blowers used on the waste heat boilers in No. 4 slabbing mill. There are three soot blowers on each boiler, and they are operated once each turn if auxiliary fuels are being fired and once each day if the boiler is operating on waste heat alone.

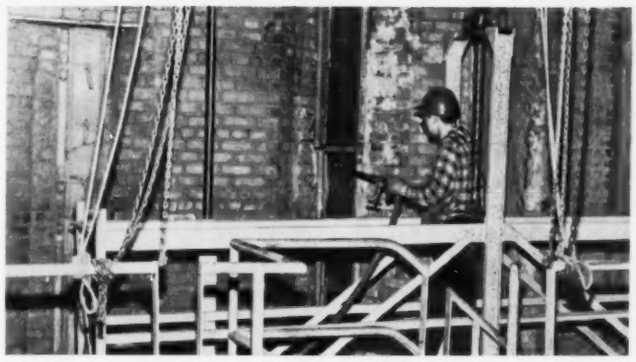


Figure 1 — Hand lancing is employed on the sectiona header boilers.

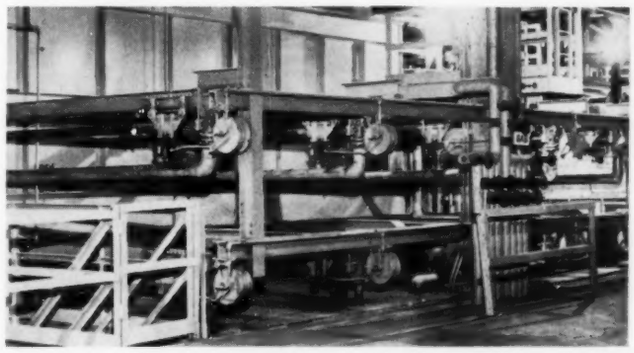


Figure 2 — The latest waste heat boilers use retractable soot blowers.

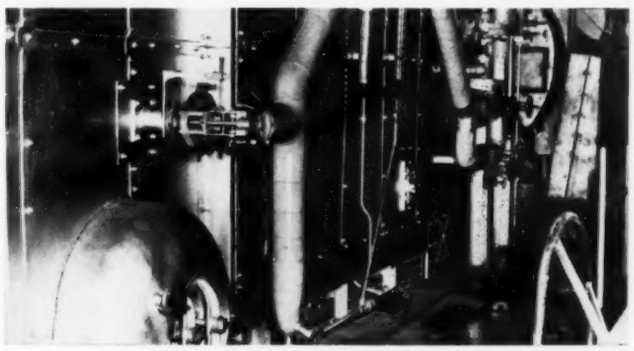


Figure 3 — Rotary hand-operated soot blowers are installed on the waste heat boilers at No. 4 slabbing mill.

The success of retractable soot blowers on the No. 3 open hearth boilers and the ten superheaters in No. 2 open hearth will certainly influence the design of any boilers purchased in the future for open hearth service. The importance of keeping boiler passages open to insure proper drafting will point to a boiler design that can use retractables for cleaning fire-side surfaces.

AUXILIARY FIRING

The burning of fuel along with waste heat was first used in 1950 when oil burners were put on five of the fire-tube boilers at No. 3 blooming mill. Burners were installed to maintain normal steam flow when the pits were down for repairs or to generate additional steam during peak steam loads. As shown by Figures 4 and 5 this is not an elaborate installation. However, these auxiliary burners have served the purpose for which they were installed very ably for the past ten years.

The success of the first auxiliary firing led to the second installation on three boilers in No. 3 open

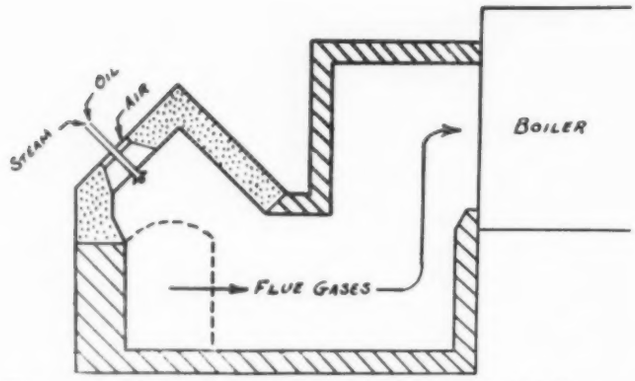


Figure 4 — Oil burners were added to several boilers to provide additional steam when waste heat was not available.

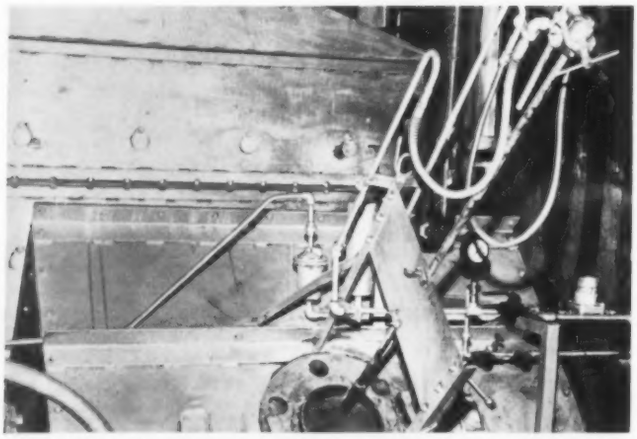


Figure 5 — Simple controls and regulation were used for the first auxiliary burner installations.

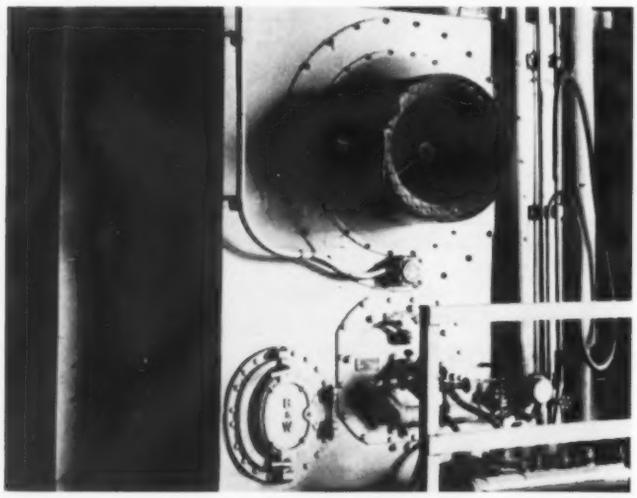


Figure 6 — Further auxiliary installations were made to increase steam availability during times of peak usage.

hearth. Figure 6 shows the oil burner, fan and wind box as they are mounted in a single unit. There are no combustion controls but settings for the fan louvers have been determined for various firing rates. An extension in front of the boiler forms the entrance for waste heat from the open hearth furnace and also the combustion chamber for firing oil with the auxiliary burner. As in the case of the oil burners on the first installation, these burners are only used when absolutely necessary to meet peak steam loads.

When waste heat boilers were considered for No. 4 slabbing mill, one of the primary factors was that these

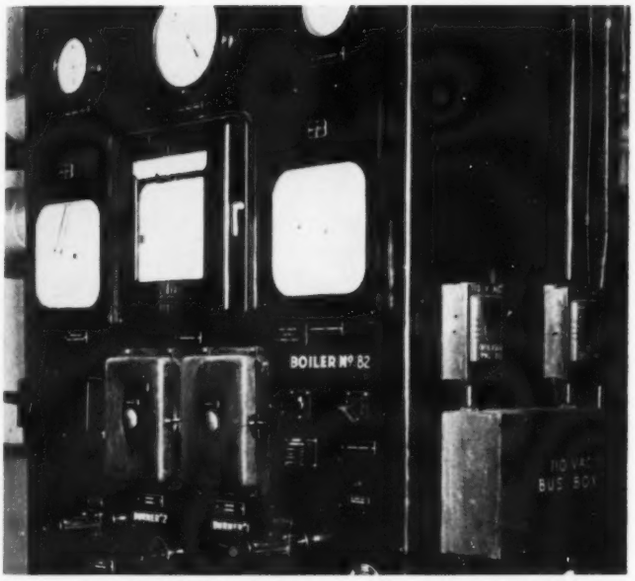


Figure 7 — Desired steam flow is set on the control panel and auxiliary firing is initiated as required to maintain a constant flow.

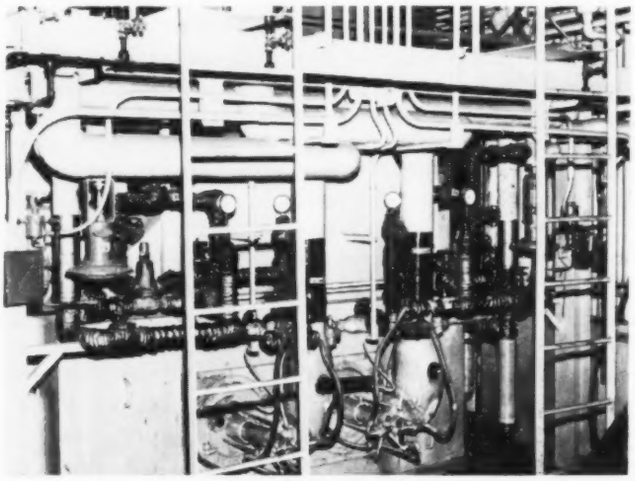


Figure 8 — Interlocks shut off the fuel in case of fan difficulties or if there is a flame interruption.

boilers must be so designed that fuels could be fired in addition to waste heat to maintain a steady steam output when required. As previously stated, the boilers chosen for this service were 2-drum bent-tube water-walled boilers with a maximum rating of 35,000 lb of steam per hr. Each boiler is equipped with combustion controls and burners to burn oil or coke-oven gas either separately or in combination. The control is positioning which maintains a preset fuel-air ratio for any fuel setting. The desired rate of steam flow from the boiler is set by means of a control knob and this flow is maintained regardless of the variation in waste heat. Figure 7 shows the panel boards with instruments and controls. Figure 8 is a front view of the boiler showing burners, valves and a portion of the platform with the forced draft fan. Safety features are interlocks on both forced and induced draft fans to shut fuel off in the event of power interruption and an electronic unit that shuts the fuel off if there is a flame failure.

The purpose of this article has been to present the use of waste heat boilers at Inland and to discuss some of the problems involved. It is hoped that the areas covered will indicate points for consideration when selecting boilers for waste heat service.

Discussion

PRESENTED BY

H. B. HELM, Assistant Superintendent, Fuel & Power Dept., The Youngstown Sheet and Tube Co., East Chicago, Ind.

W. M. DOUGLAS, Assistant Superintendent, Power, Steam and Combustion Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

H. B. Helm: At the Indiana Harbor works of The Youngstown Sheet and Tube Co. waste heat is also used as a so-called free fuel for steam generation. Steam generation from waste heat is confined to open hearth furnace shops: nine waste heat boilers in the No. 1 open hearth shop are each rated at 15,000 lb per hr, and eight in the No. 2 shop are each rated at 30,000 lb per hr, making a total rated capacity of 375,000 lb per hr. All but the four oldest boilers are of the fire-tube type.

The feedwater treatment is somewhat different in that feedwater for all boilers including high-pressure boilers is treated at one location, the high-pressure boilerhouse, and piped to the waste heat boilers.

Continuous blowdown is the practice in the newer shop whereas periodic hand blowdowns are used in the No. 1 shop, in each case, for the purpose of controlling chlorides. When the boilers are shutdown for annual inspection no special cleaning is done other than routine washing with water. The fire-tube boilers are turbined at the end of each open hearth furnace campaign solely for the purpose of cleaning the fire side since there is no sludge or scale formation. Acid cleaning has never been required on any of the waste heat boilers.

Our experience with plugging of the waste gas passes through the superheater tubes is much the same as the author's particularly with the finned castings.

The soot-blowing practice is also similar. The fire-tube boilers in No. 1 shop are hand lanced once each day. The No. 2 shop boilers are equipped with rotating soot blowers which are operated once each turn. In all cases steam is used as the blowing medium.

In the past few years, the firing rates on the No. 2 open hearth furnaces increased to such an extent that the volume of waste gases became more than the boilers could handle. This condition not only created a draft control problem but also resulted in overfiring of the boilers, beyond a safe point. In order to solve the problem, a control was installed on the boiler by-pass damper tied into steam flow from the boiler as well as to furnace pressure. With this system the waste heat boiler and boiler damper handle all waste gases up to a point where a maximum preset quantity of steam is generated. A further increase in the quantity of fuel fired, results in the boiler by-pass damper taking over as the furnace pressure control since the boiler is limited to its safe maximum rate of steam generation. This system has worked very satisfactorily.

What is the pressure and source of the compressed air used for soot blowing? If it comes from a separate system rather than plant air, would the author care to comment on this?

Have there been any probiems with excessive plugging or overfiring the boilers, due to increased firing rates or the use of oxygen?

W. M. Douglas: Air is used directly from the plant air system, and the pressures will range between 60 and and 90 psig.

An example of the type of difficulties experienced occurred in No. 2 open hearth shop. The furnaces in the south half of this shop have been enlarged twice, the furnace tonnage capacity and fuel input rates being increased each time. Furnace drafting limitations were relieved by shortening every other element of the hair-pin type superheater thereby considerably reducing the pressure drop across the superheater. Additional relief was obtained by improving flue blowing practices.

The use of increasing quantities of oxygen has affected induced draft fan performance. Deposits accumulate faster on the fan. Induced draft fans operating on furnaces using larger quantities of oxygen must be scaled, cleaned and rebalanced more frequently than fans operating on furnaces consuming no oxygen.

There are four furnaces in No. 3 shop operating at rates restricted by the inability to maintain adequate draft. Consideration is being given to the alteration of the waste heat boilers on these furnaces in a manner that these draft restrictions will be removed or minimized.

Member: Has the author noted any direct effects due to using auxiliary burners in conjunction with the waste heat boiler; also has he any figures on boiler efficiency with auxiliary firing?

Would the author elaborate on the retractable blower, has there been any trouble with heat, water cooling or metallurgy?

W. M. Douglas: There has been little, if any, detrimental effect on the boilers caused by auxiliary firing. No doubt, there has been some wear due to auxiliary firing, but the wear has been so small that it has not been a problem. The auxiliary burners of the higher capacities are located on recently installed boilers with specified capacities to accommodate the firing of auxiliary fuel. The last auxiliary burner installation was applied to the 35,000 lb per hr waste heat boilers located on soaking pits at No. 4 slabbing mill. The heat distribution is very good throughout these boilers, whether operation is on waste heat or auxiliary burners. The boilers have water-wall tubes. Operation of the auxiliary burners causes no overload on the boilers.

It is just a matter of time until higher air pressures are used for soot blowing. It would seem quite obvious that a better job of tube cleaning can be accomplished with 300-psi air than can be done with the air pressure presently used. There is reluctance to return to the use of steam in certain soot-blowing applications because it is felt that air can be used as effectively and more safely than steam.

The retractable soot blowers have operated satisfactorily and have given little trouble. Retractable soot blowers installed in the hotter locations of the boilers are alloy, those located in cooler locations are plain carbon steel.

Member: How do you take care of the fume that comes from the operation of your boilers?

W. M. Douglas: Fumes from furnace reactions are allowed to pass through the waste heat boiler through the induced draft fan into the stack. Nothing special is provided for collecting fumes carried in the furnace gases. ▲

Automatic Gage Control As A Function of Transport Distance

by D. E. VARNER

Chief Control Project Engineer, Industrial Nucleonics Corp., Columbus, Ohio

. . . . with the use of higher speed mills the transport lag and the system time constant have become important factors in gage control . . . . increasing the speed of control and increasing the correction percentages available can appreciably affect the strip quality, i.e., a 10-per cent error can be reduced to under one per cent in less than two transport lag time cycles . . . .

THE general configuration of a 5-stand tandem mill is shown on Figure 1. The basic principle of speed, tension control on such a mill is simple: the product of strip speed and thickness must be a constant throughout the mill. Therefore, if stand No. 1 is slowed down, the output gage will become thin. Or, if stand No. 5 is speeded up, the output gage will become thin. This principle applies to most multiple stand mills where sufficient power is available at the stand in question. As the rolling process is a complicated function, no attempt will be made to explain the relation between speed and tension. It may be said, however, that tandem mills are generally controlled through the speed regulating circuits, while reversing mills are controlled through the tension regulating circuits. On a reversing

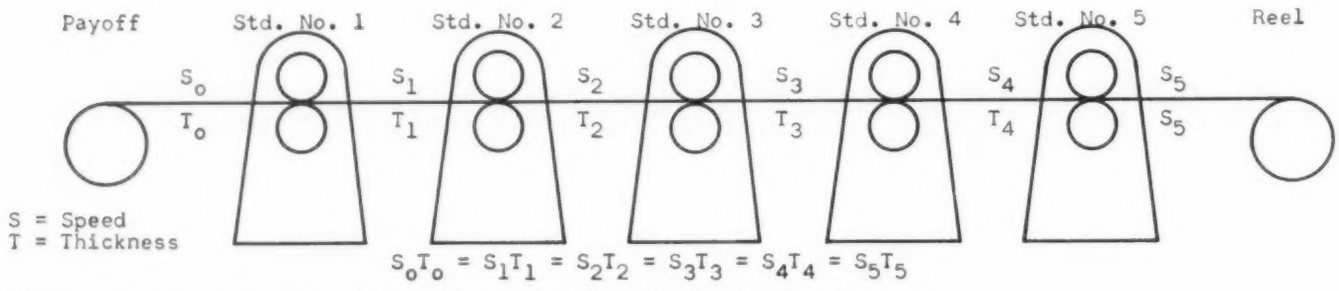


Figure 1 — There are three possible modes of control considered for the 5-stand mill.

Figure 2 — Two operating modes are considered for control of the 4-stand mill.

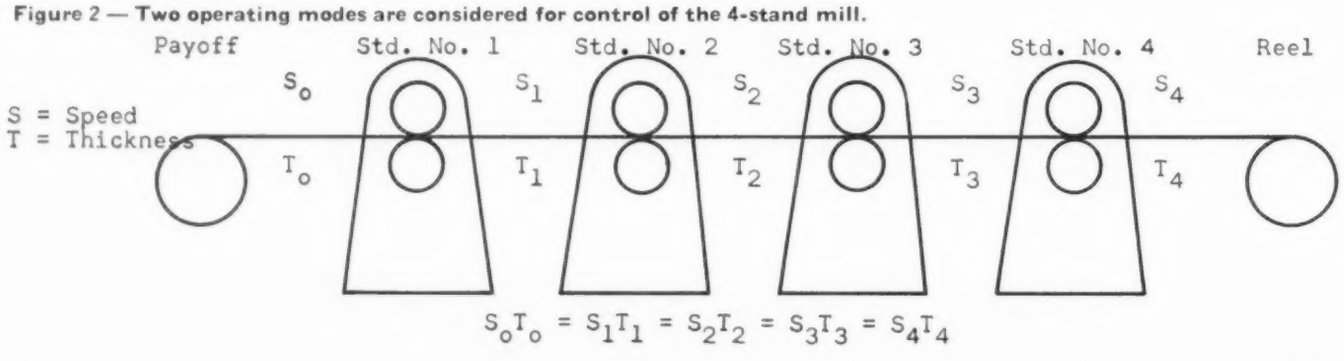


TABLE I
Control Characteristics—5-Stand Mill

Mode No. 1, Field control	1. Speed control of stand No. 5. 2. Changes back tension on stand No. 5. 3. Changes front tension on stand No. 4. 4. Short transport lag. 5. Used successfully on tin-plate mills.
Mode No. 2, Armature control	1. Speed control of stand Nos. 1, 2, 4 and 5. 2. Pivot about stand No. 3. 3. Speed change: ±5 per cent on stand No. 5; ±3 per cent on stand No. 4; ±2 per cent on stand No. 2; ±1 per cent on stand No. 1. 4. Transport lag longer than mode No. 1. 5. Better load distribution than mode No. 1.
Mode No. 3, Armature control	1. Speed control of stand Nos. 4 and 5. 2. Changes back tension on stand Nos. 5 and 4. 3. Changes front tension on stand Nos. 3 and 4. 4. Transport lag, a compromise between mode Nos. 1 and 2. 5. Good load distribution with fairly short transport lag.

TABLE II
Control Characteristics—4-Stand Mill

Mode No. 1, Field control	1. Speed control of stand No. 4. 2. Changes back tension on stand No. 4. 3. Changes front tension on stand No. 3. 4. Short transport lag. 5. Used successfully on tin-plate mills.
Mode No. 2, Armature control	1. Speed control of stand Nos. 1, 2 and 3. 2. Speed changes all in same direction. 3. Speed change: ±10 per cent on stand No. 1; ±5 per cent on stand No. 2; and ±3 per cent on stand No. 3. 4. Long transport lag. 5. Heavily loaded mills.

TABLE III
Control Characteristics—Single-Stand Reversing Mill

Mode No. 1	1. Tension control. 2. One reel motor connected as drag generator. 3. Other reel powered to pull with mill motor. 4. Useful on thin steels and nonferrous metals. 5. Most common control is screwdown or combination of screw-down tension control.

mill an increase in either right or left reel torque will reduce the strip thickness.

The number of possible control modes is a function of the number of stands, the amount of power available in each stand and the material being rolled. Three modes which have been used on a 5-stand mill are shown in Table I.

The 4-stand mill (Figure 2) is a more difficult control problem than the 5-stand mill. Two operating modes are shown in Table II. As a general rule, production has been increased to the point where at least one stand is underpowered. This leads to the distribution of control where the mill has reserve power. Mode No. 2 is a good example of distributed load. Most control takes place at stand 1, with a resultant large transport lag.

Most reversing mills (Figure 3) are controlled by a combination of screw-down and tension adjustment. Tension control is used on steel below 0.040 in., and screw-down control is used on thicknesses above 0.040 in., see Table III. The sendzimir mill is usually controlled by hydraulic screwdown. Figures 4 and 5 show an installation using tension control and an installation using speed-tension control respectively.

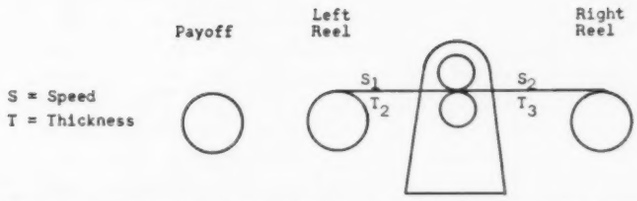


Figure 3 — Single-stand mills are generally controlled by combined screw-down and tension control.

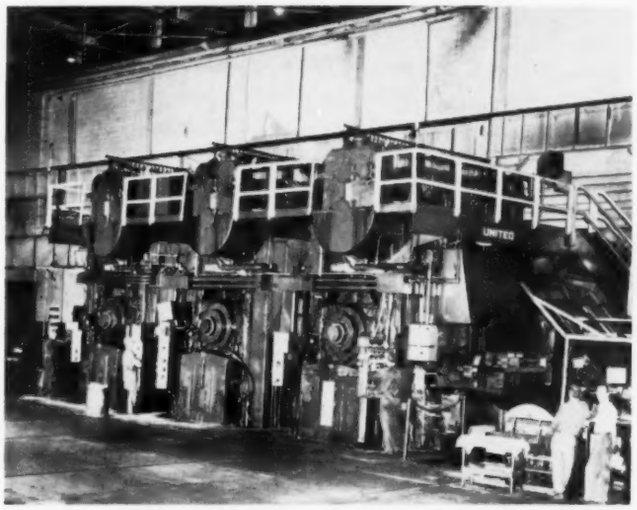


Figure 4 — Gage measurement takes place after the last stand.

Figure 5 — Mill speed-tension parameters are set at the operator's control station.

ARMATURE CONTROL VS FIELD CONTROL

The speed of d-c motors may be controlled by either armature voltage or field current. Usually a d-c motor is started with full-field current and low armature voltage. The speed is increased gradually under controlled acceleration by increasing the armature voltage. At

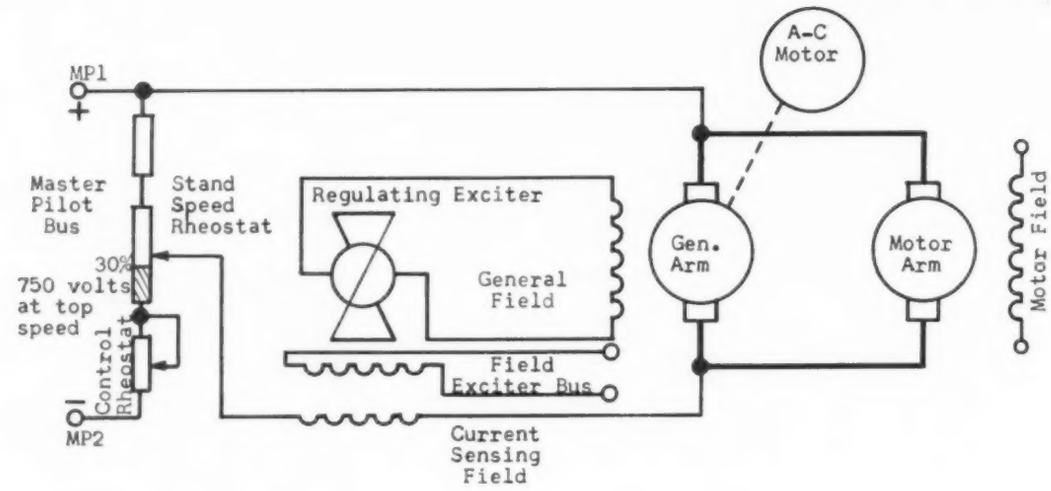


Figure 6 — Control in the armature circuit can be accomplished with the use of a rotating amplifier.

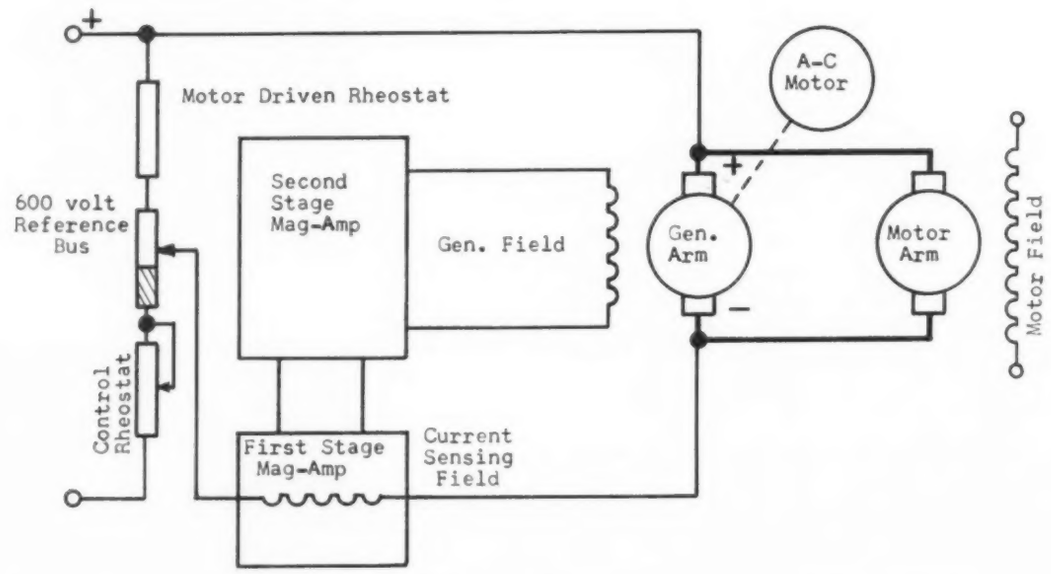


Figure 7 — Control in the armature circuit can be accomplished with the use of a magnetic amplifier.

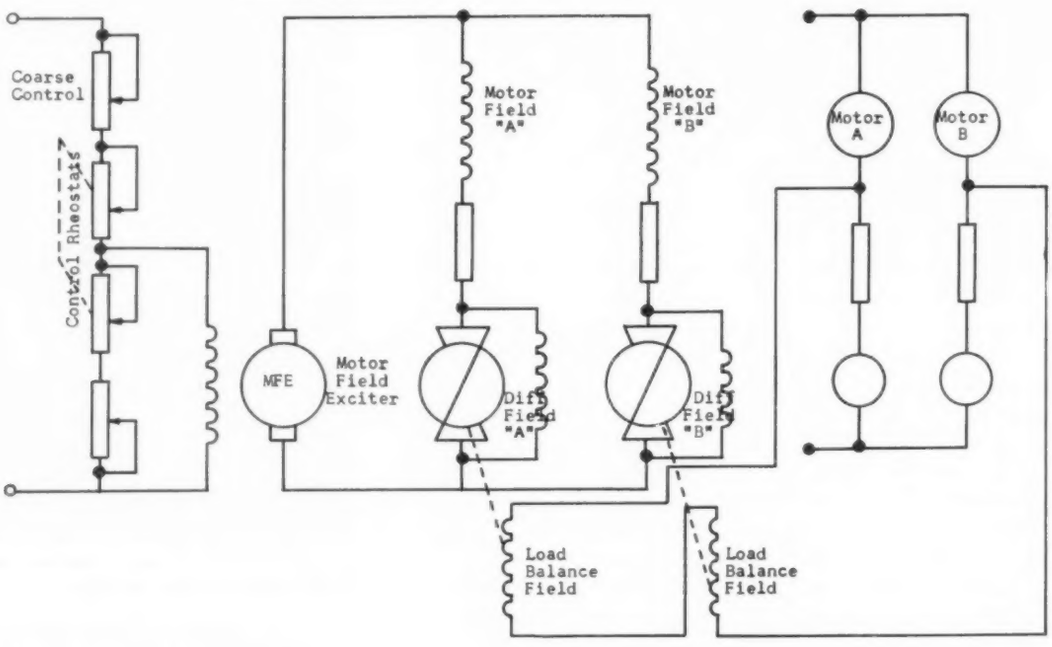


Figure 8 — Motor field control can be used, but the response time is greatly increased.

some certain speed, called base speed, the armature voltage reaches a maximum; further increases in speed are made by weakening the field. Speed is related to armature voltage and field current by the following equations:

$$E_a = K_1 N \Phi$$

$$N = \frac{K_2 E_a}{\Phi} = \frac{K_3 E_a}{I_f}$$

$$\Phi = K_4 I_f$$

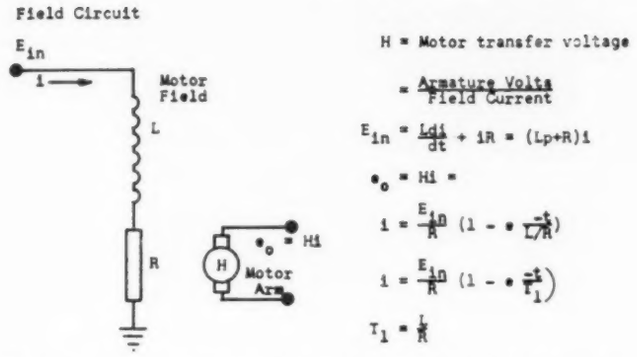


Figure 9 — A mathematical analysis is presented for the field circuit control.

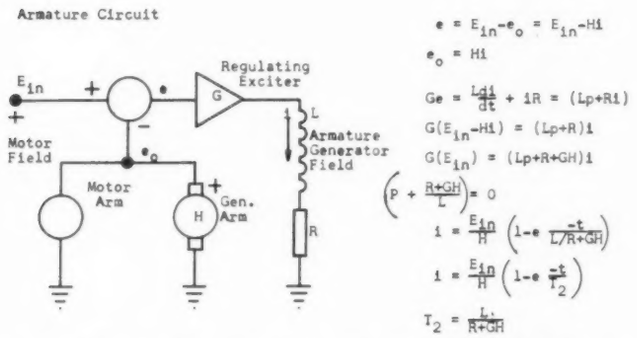


Figure 10 — A mathematical analysis is presented for the armature circuit control.

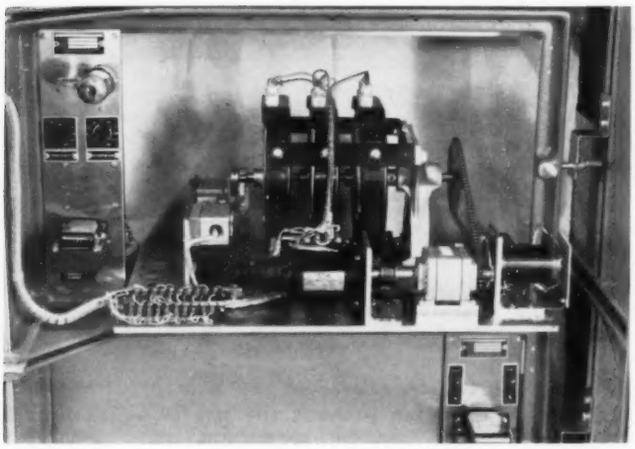


Figure 11 — A servo-operated rheostat can be used to maintain a null balance in the armature circuit.

N = speed, rpm
E_a = armature voltage
Φ = field flux
I_f = field current
K_1, K_2, K_3 and K_4 = constants

Therefore, the speed of a tandem mill may be controlled either by adjusting field current or armature voltage. It should be noted that for a given field current a ten per cent change in armature voltage results in a ten per cent speed change. Or, for a given armature voltage, a ten per cent change in field current results in almost a ten per cent change (9.09 or 11.1 per cent) in speed.

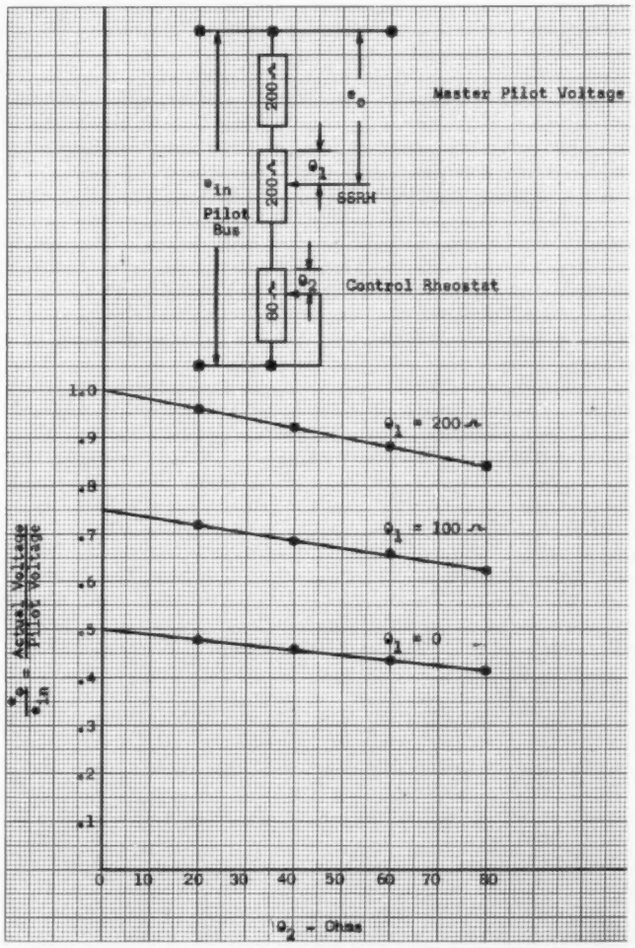
The decision, whether to use armature or field control, is usually made for us by the fact that the armature circuit includes a regulating loop that appreciably reduces the electrical time constant. The circuits of Figures 6 and 7 have an electrical time constant of about 0.150 sec, while the circuit of Figure 8 has a time constant of about 1.5 sec. A mathematical analysis is shown on Figures 9 and 10. The reduced time constant is the reason most controls are in the armature circuit.

The speed of a tandem mill is regulated about the master pilot voltage. Each stand is synchronized to run at a certain speed in relation to all the other stands. The operator sets this relation with the individual stand speed rheostat. The control signal is usually inserted in series with the master pilot voltage, see Figures 6 and 7. The rotating or magnetic amplifier senses any voltage difference between the armature and master pilot voltage and corrects the armature voltage until a null balance is reached. It is this regulating loop that effectively reduces the time constant of the armature circuit. One simple and economical control element is the servo-operated rheostat, shown in Figure 11. High-quality ball bearing rheostats assure years of trouble-free service. Figures 12 and 13 are plotted to show the effect of the control rheostat on a pilot voltage signal supplied to a mill. The curves are almost linear, assuring uniform gain over the full travel of the rheostat.

PROPORTIONAL CONTROL

Three types of control are easily applied to these circuits. The first type is proportional control, in which stand speed is changed in direct proportion to an error.

Figure 12 — Near linear curves assure uniform gain over the full rheostat travel.



The proportionality constant is the ratio of change in controlled variable to error:

$$K_p = \frac{\text{per cent speed change}}{\text{per cent error}}$$

Where transport lag, the distance between measurement and control points, may be neglected, this system is a simple "Type O" servo system. Unfortunately, in most practical systems transport lag may not be neglected; this is particularly true in the case of proportional control. As shown in Figures 14 and 15, the gain (K_p) is limited to values less than unity. Values of K_p greater than unity cause destructive instability. This means that any given error cannot be reduced by more than 50 per cent.

$$\frac{\text{Output}}{\text{Input}} = \frac{K_p}{1 + K_p} = \frac{1}{1 + (1/K_p)} \leq \frac{1}{2}$$

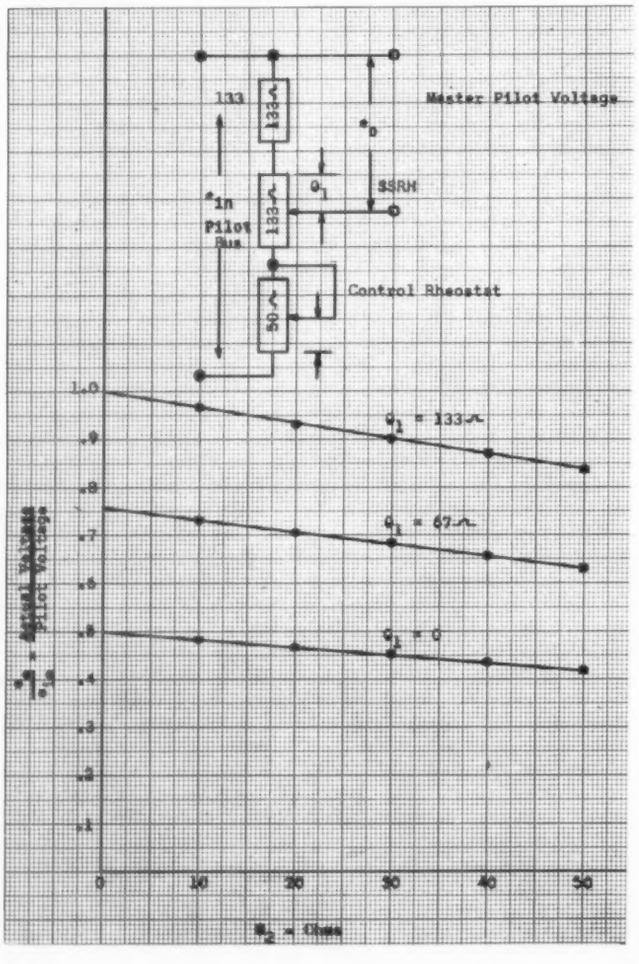
$$\text{Error} = \frac{\text{Input}}{1 + K_p} \geq \frac{\text{Input}}{2}$$

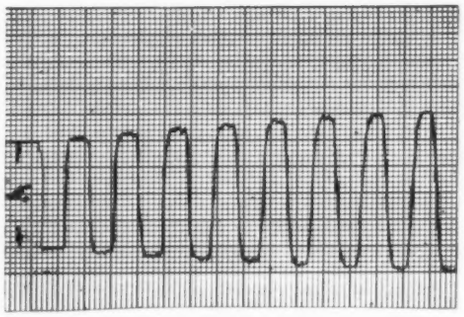
This type of system is, therefore, not useful as a controller without the addition of other elements.

INTEGRAL CONTROL

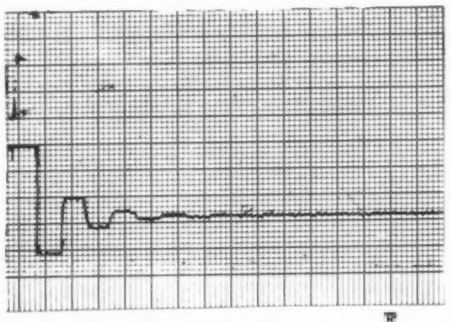
The second type is integral (reset) control, in which stand speed is changed at a rate proportional to error, see Figures 16 and 17. The proportionality constant is known as the velocity constant (system gain) and is the

Figure 13 — The effect of the control rheostat on pilot voltage signal is illustrated.

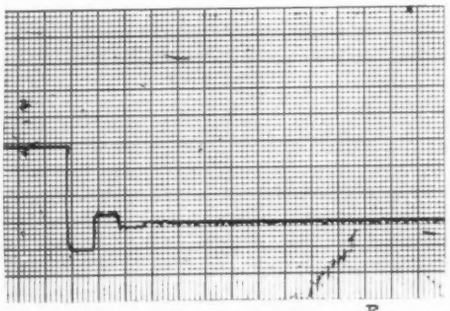




K_p = 1.1; Unstable System



$K_p = \frac{1.1}{2}$; Steady State Error = $\frac{E_o}{1+K_p}$ = .647 E_o



$K_p = \frac{1.1}{3}$; Steady State Error = $\frac{E_o}{1+K_p}$ = .732 E_o

Figure 14 — Error signal proportional control is limited to 50 per cent correction without the use of other circuit elements.

ratio of rate of change of controlled variable to error:

$$K_v = \frac{\text{per cent speed change per sec}}{\text{per cent error}}$$

Where transport lag may be neglected, this system is a "Type 1" servo system.

An analysis of the transient response to a step function such as a weld is as follows: the rate of change of the error is proportional to the error or,

$$\frac{dE}{dt} = -K_v E$$

A solution to this differential equation is:

$$E = E_0 e^{-K_v t}$$

The change in mill speed and in the error (E_0) from t =

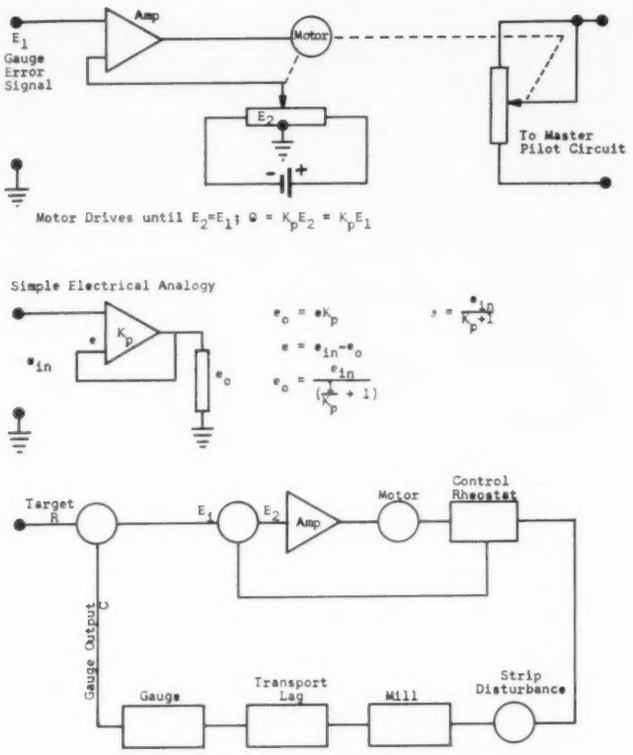


Figure 15 — K_p is limited to values of less than one.

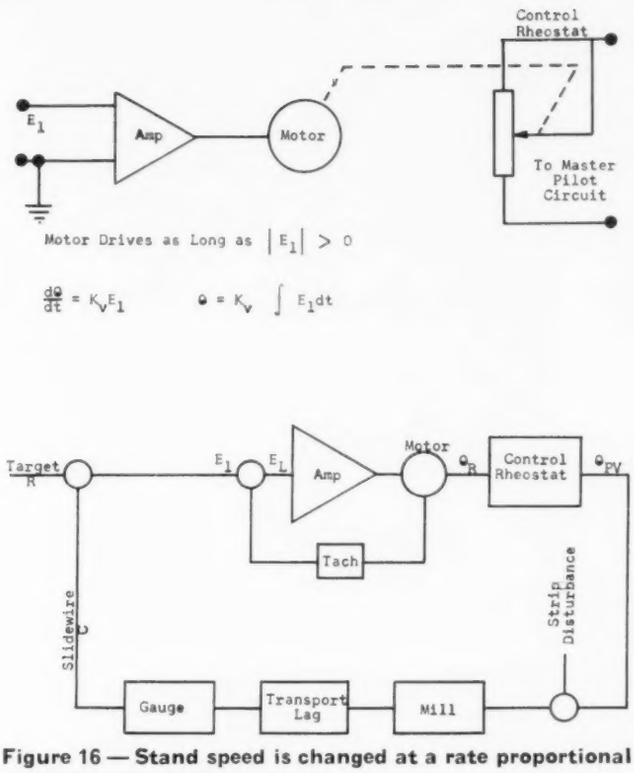


Figure 16 — Stand speed is changed at a rate proportional to the measured error.

0 to $t = t_1$ is:

$$\Delta E = \Delta S = -K_v \int_{t=0}^{t=t_1} E_0 e^{-K_v t}\, dt$$

$$= E_0 (1 - e^{-K_v t_1})$$

The product $K_v t_1$ is an important factor in calculating circuit constants. When $t_1 = 1/K_v$ the error has been reduced to 36.8 per cent of the original value. From this relation it is possible to establish stability as a function of process delay. Intuitively the system will be stable for a velocity constant equal to:

$$K_v = \frac{1}{NT_1}$$

T_1 = process lag, sec
N = some integer larger than one

The particular case of a transport lag is plotted in Figure 12. The dotted curves show the decay of an error in a theoretical system where all time constants and lags are neglected. The solid curves show the effect of transport lag only. These curves show that where transport lag is much larger than other lags, the velocity constant may be adjusted to give the curve:

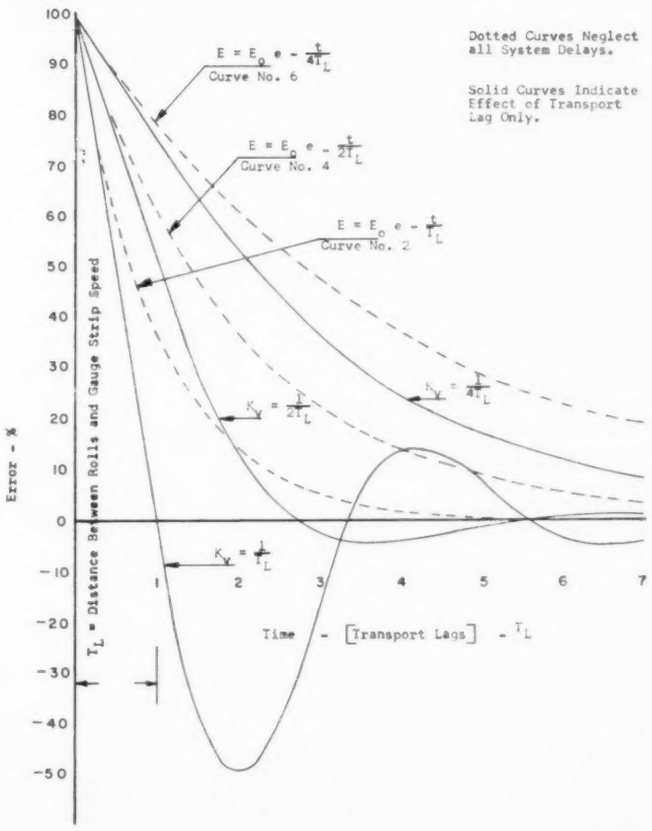
$$K_v = \frac{1}{2T_L}$$

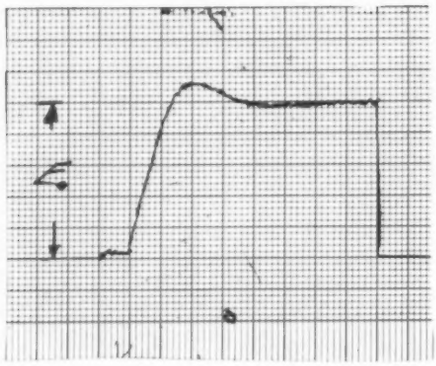
where T_L equals transport distance in sec. In more complicated systems with several lags, the value $K_v = 1/4T_L$ or smaller may be necessary. From the curve $K_v = 1/2T_L$, a 10-per cent error is reduced to within a value of less than one per cent in two transport lags. The steady state error for all values of K_v is theoretically zero.

PROPORTIONAL PLUS INTEGRAL CONTROL

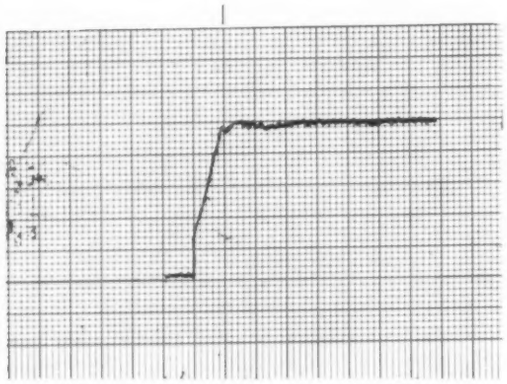
The integral or reset controller is then the most practical for any system with transport lag. Where the process economics warrant, a further improvement can be made by the addition of proportional control. Re-

Figure 17 — Error decay as a function of T_L for integral control is illustrated.

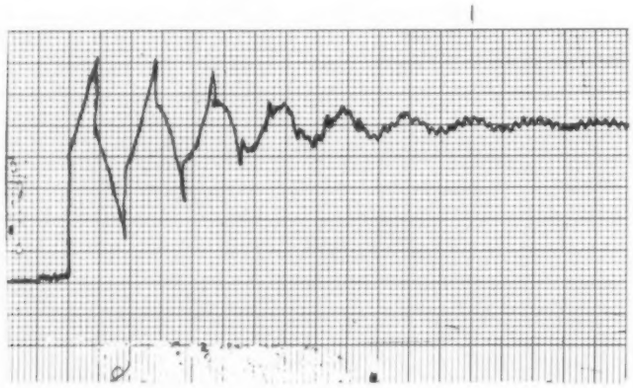

Dotted Curves Neglect all System Delays.
Solid Curves Indicate Effect of Transport Lag Only.
$E = E_0 e^{-\frac{t}{4T_L}}$ Curve No. 6
$E = E_0 e^{-\frac{t}{2T_L}}$ Curve No. 4
$E = E_0 e^{-\frac{t}{T_L}}$ Curve No. 2
$K_v = \frac{1}{4T_L}$
$K_v = \frac{1}{2T_L}$
$K_v = \frac{1}{T_L}$
Error - %
T_L = Distance Between Rolls and Gauge Strip Speed
Time - [Transport Lags] - T_L



$$K_v = \frac{1}{1.4T_L}, \quad K_p = .1$$



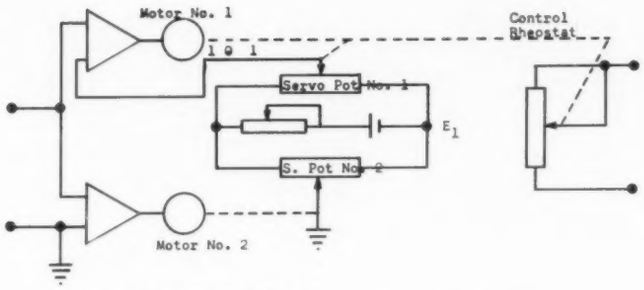
$$K_v = \frac{1}{1.4T_L}, \quad K_p = .3$$



$$K_v = \frac{1}{1.4T_L}, \quad K_p = .8$$

Figure 18 — Proportion control plus integral control can reduce transport lag.

corder charts, made during a computer study, show the comparative results, see Figures 18 and 19. The integral system velocity constant has been increased from $1/2T_L$ to $1/1.4T_L$ and the proportional system constant set at $K_p = 0.3$. A 10-per cent error is now reduced to one per cent in one transport lag. The computer study showed these to be the optimum settings for a system where the transport lag is much larger than other system lags.



Motor No. 1 Drives until $E = E_1$

Motor No. 2 Drives as Long as $E_E > 0$

$$\theta = K_p E + K_v \int E dt$$

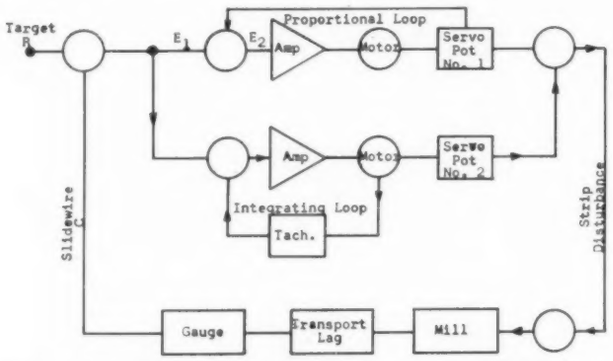
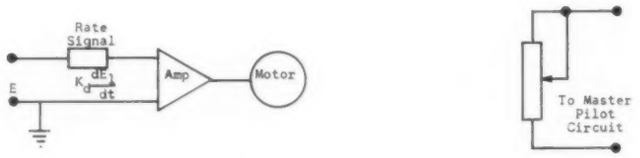


Figure 19 — Schematic illustrates integral control plus proportional control.



Motor Drives as Long as $\left| E + K_d \frac{dE}{dt} \right| > 0$

$$\frac{d\theta}{dt} = K_v\left(E + K_d \frac{dE_1}{dt}\right) \qquad \theta = K_v \int \left(E + K_d \frac{dE}{ddt}\right) dt$$

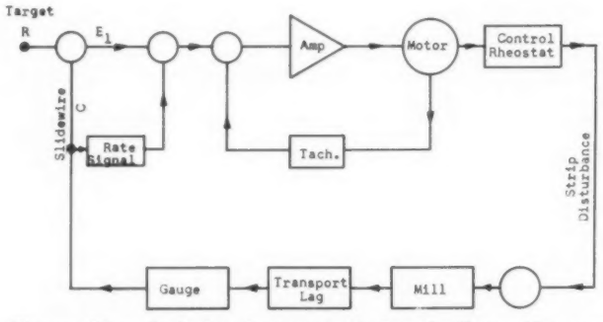


Figure 20 — A derivative control signal allows the use of higher system gains with integral control.

DERIVATIVE CONTROL

The third type is derivative (rate) control, in which a signal proportional to the derivative of the error is added to the error signal. The signal to the amplifier is then:

$$E' = E + K_d \frac{dE}{dt}$$

The proportionality constant is the ratio of equivalent error signal to rate of change of error.

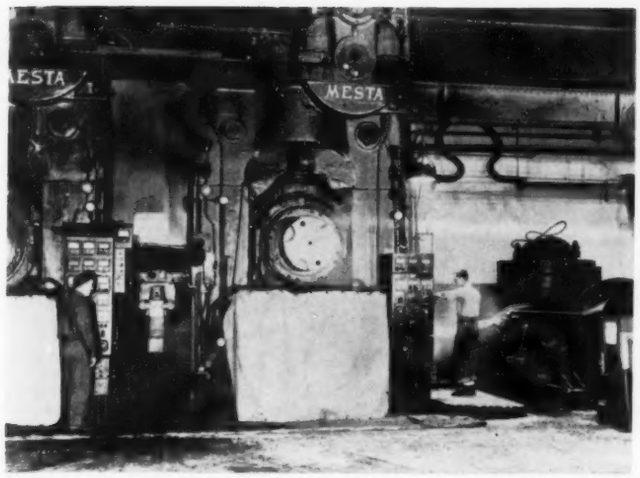


Figure 21 — The signal from the gage actuates the No. 1 stand screwdown.

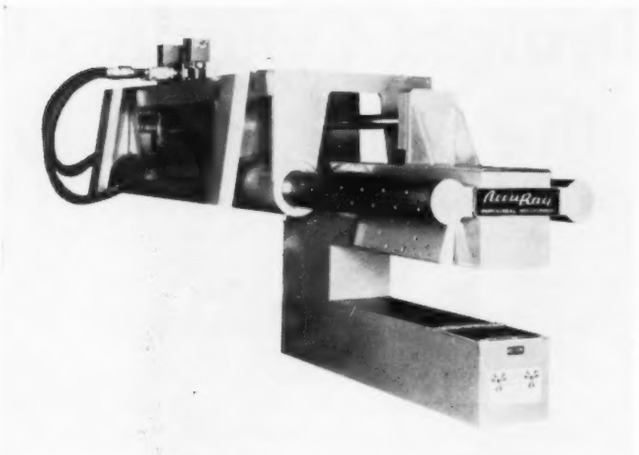


Figure 22 — The strip is measured by a thickness gage.

$$K_d = \frac{\text{per cent error}}{\text{per cent error change per sec}}$$

The derivative signal may be obtained either from a tachometer geared to a measuring slidewire or a conventional phase lead network. It is most useful in conjunction with an integral system which has an inherent 90-degree phase lag. The derivative signal, having a 90-degree phase lead, allows the use of higher system gains.

A complete system is shown on Figure 20. With this circuit a 10-per cent error will be reduced to one per cent in about 1.5 T_L.

FIRST STAND SCREW-DOWN CONTROL

All tandem mill systems mentioned in this article have a gage and screw-down control system at the first stand, see Figures 21 and 22. This may be considered a coarse control and is useful in maintaining a relatively constant thickness from the first stand, which is independent of changes in the hot band.

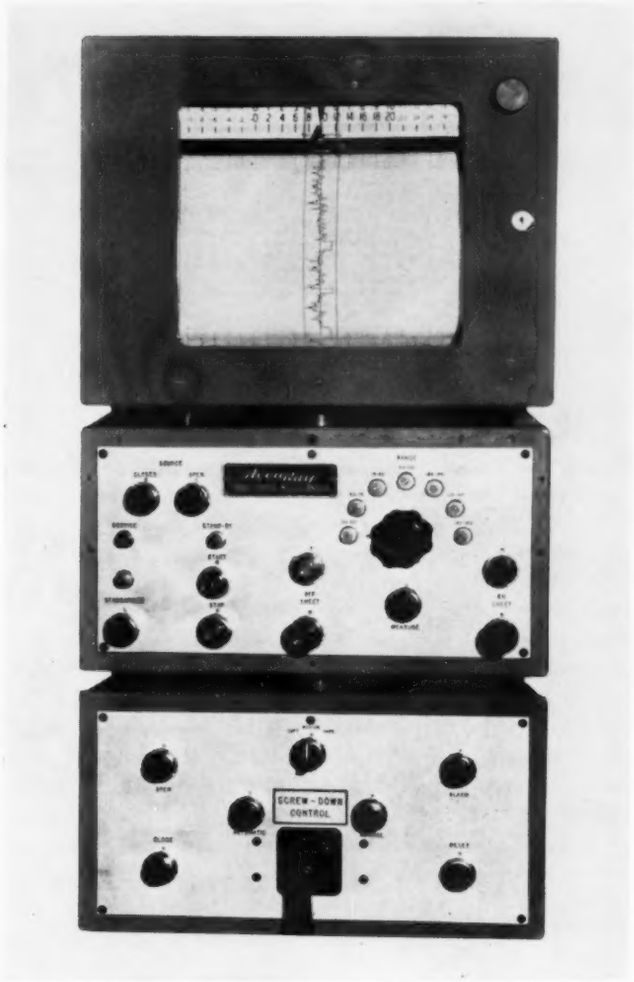


Figure 23 — Recorders may be used to give a permanent record of strip gage.

SUMMARY

Automatic gage control can be designed to match most metal rolling processes from only a basic knowledge of the rolling schedules and mill dimensions. For a process with transport lag, an integrating type control must be the heart of the system. An integrating control with derivative signal will reduce a 10-per cent error to a final value of less than one per cent in about 1.5 T_L. The standard deviation of the output gage as shown on the recorder charts (Figure 23) is well under ± one per cent. ▲

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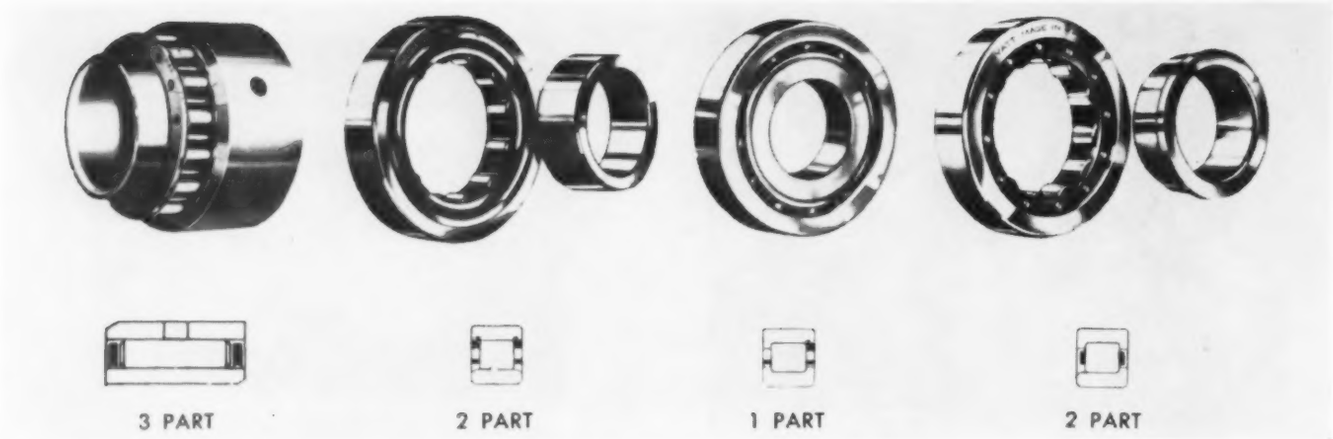

Figure 1 — There are several type assemblies for the straight cylindrical bearing.

Why Straight Cylindrical Bearings in the Steel Industry

by PHILIP H. HUTCHINSON
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. . . . selection of the proper type and size of bearing must consider, in addition to the usual stress computation, original cost, maintenance cost and type of maintenance which the bearing will receive . . . .

IN recent years there has been a considerable increase in the various types and sizes of anti-friction bearings made available to industry. It has also been noted that the design or application engineer faced with the problem of bearing selection for a given application has as much difficulty selecting the type of bearing he wants to use as he does selecting the bearing of proper capacity.

The straight cylindrical bearing has often been referred to as the "work horse" in the bearing industry. This fact was recognized by steel mill design engineers 45 years ago, and since that time straight cylindrical bearings have played a major role in the steel industry.

The inherent characteristics of the straight cylindrical bearing will be related to a number of specific major steel mill applications. Recognizing the increasing emphasis being placed on new application costs and maintenance, the economic factors relating to the subject will also be discussed.

For the purpose of this discussion, the straight cylindrical bearing should be defined as a bearing with the rolling elements having parallel sides. These rollers may have various L/D (length over diameter) factors. Straight cylindrical bearings are available in a variety of types, see Figure 1.

The advantage of the 3-part bearing is that the bearing may be applied with or without inner or outer races. If races are omitted, the shaft or housing bore must be hardened. Another advantage is that component parts may be assembled prior to unit assembly, and after assembly no adjustments are necessary. From a maintenance standpoint, component parts may be stocked and replaced separately, where only one part has failed or become damaged, eliminating the necessity of scrapping a completed bearing as is necessary with a 1-part bearing. A disadvantage of the 3-part bearing is that external means of locating parts must be provided. The 3-part bearing is designed for pure radial loads and cannot take any thrust loads.

The 2-part bearing with roller assembly retainment eliminates the necessity of external location of the roller assembly. It has the advantage of being applied with inner race integral with the shaft. Generally, this type of bearing is available at the lowest cost for a given rated capacity in the metric series line. An important advantage of the 2-part bearing, as well as the 3-part bearing, is that in the application of the bearing the relative location of the races is not critical. This allows

for positive location of inner and outer races, and eliminates the necessity for critical control of axial tolerances and adjustment. At the same time, it allows the bearing to adjust itself laterally due to ambient temperature changes without requiring the outer race to float in the bore, as in the case of 1-part bearings, and without causing a change of internal clearance as in the case of adjustable-type angular contact bearings.

The 1-part bearing eliminates the necessity of locating the outer race and roller assembly where the inner race is held. The bearing has the advantage of assembly in a blind location; however, where ambient temperature changes are great, the outer race must float in the bore in order to locate itself relative to the inner race. The 1-part bearing (Figure 1) can take lateral location in one direction. Where two bearings are used and the outer race flanges are mounted opposed, location may be taken axially in both directions.

Also shown in Figure 1 is a 2-part flanged race bearing. This bearing is available in many types such as:

1. Double flanged inner race with single flanged or straight outer race.
2. Double flanged outer race with single flanged or straight inner race.

The retainer of this type bearing is generally made of steel or bronze and fabricated. This type of bearing is generally the most expensive for a given rated capacity in the metric series line. Its application is generally for heavy duty applications and where speed and/or noise is a consideration. The bearing has the application advantages of 2-part bearings as noted above, as well as the ability to take thrust.

The basic engineering concepts of straight cylindrical bearings are important in selection of bearings for steel mill applications, for it is an accepted fact that the straight cylindrical bearing gives the greatest radial load carrying capacity for a given annulus of any antifriction bearing available. Naturally, there are many elements of design and manufacture which affect the ultimate performance in the application.

Internal clearance, often called radial looseness, plays an important part and must be based on consideration of such factors as the bearing race fits, the range of loads under which a bearing will be required to operate, the temperature variations across the bearing and the degree of misalinement in the application. The amount of roller crowning, a concept developed many years ago to eliminate high concentrated stress at roller ends, must be considered for all conditions of the application. Factors which are controlled in manufacturing such as metallurgy, dimensional controls and finishes all play an important part and a good balance of design and control is necessary to assure maximum capacity and resultant life in a given application. How these factors apply to specific applications will be discussed later.

Another important consideration in the decision to select a particular type bearing should be the environmental factors of the specific application. These factors will vary from mill to mill and by application. Generally, bearings selected for steel mill applications are required to withstand heavy loads under direct shock or vibrational shock at relatively slow speeds. A wide range of ambient temperature variations, from down turns in winter to operating turns in summer, must be considered. Dirt conditions are generally severe.

Preventive maintenance programs have been stressed in recent years and as a result considerable improvement has been realized. This is particularly true in the selection of lubricants and control of frequency of lubrication; however, there are still many mill applications where marginal lubrication and maintenance must be considered. Unskilled mechanics are still employed by many mills to maintain equipment, particularly industrial cars.

In order to understand and evaluate the use of straight cylindrical bearings in the steel industry, it is important to understand some of its history. Straight cylindrical bearings were one of the first bearing types applied to steel mill equipment. First applications were to roller tables replacing plain bearings, which proved troublesome from a wear, maintenance and power consuming standpoint. Early applications were 2-part bearings applied on a change-over basis. The bearing annulus had to meet space limitations established by plain bearing sizes. Hardened roller necks were required and since it was difficult and costly to obtain proper hardness, and costly to scrap journals when wear did occur, inner races were soon added. Initial applications proved so successful that mills started extensive change-over programs and builders quickly adopted these designs. Application of similar type 2 and 3-part bearings followed on lineshafts, drives, cranes, cars and motors. In most early applications, location was provided by plain thrust washers. As speed and loads increased, dual-purpose angular contact bearings were adopted on the drive side of table rollers, one end of lineshafts and in gear drive units to maintain accurate location of gears.

As speeds and loads continued to increase, bearings of greater capacity were required. The tendency was to increase bearing length within the same annulus. It is now known that in some cases this was carried to extremes; however, in most cases, costly pattern changes as well as space limitations involved, left no alternative. In recent years some of these problems have been recognized by the builders, and they have taken steps to adopt bearings of better proportions.

One important consideration which is often neglected when evaluating bearing application performance as a factor in new designs is the effect of tax laws on depreciating new equipment. Due to these restrictions, mills have often been forced to rebuild and modernize rather than replace existing equipment, in some cases two or three times. Often loads increase 200 to 300 per cent. Very often the equipment can stand the increase structurally, but the bearings become the weak link, since more often than not space limitations and limiting shaft stresses determine how much capacity can be built into a given space. This situation has had a secondary effect in forcing the bearing industry away from product standardization, thereby increasing bearing costs.

One of the major applications for anti-friction bearings today in the steel mill is roller tables. Bearings employed on table rollers are subjected to severe shock loading under widely varying temperatures. This is particularly true of bearings employed on furnace tables, main tables and feed rollers. Bearings are also

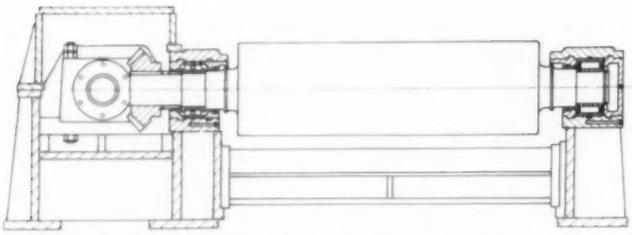


Figure 2 — Angular contact bearings are used to take the gear thrust.

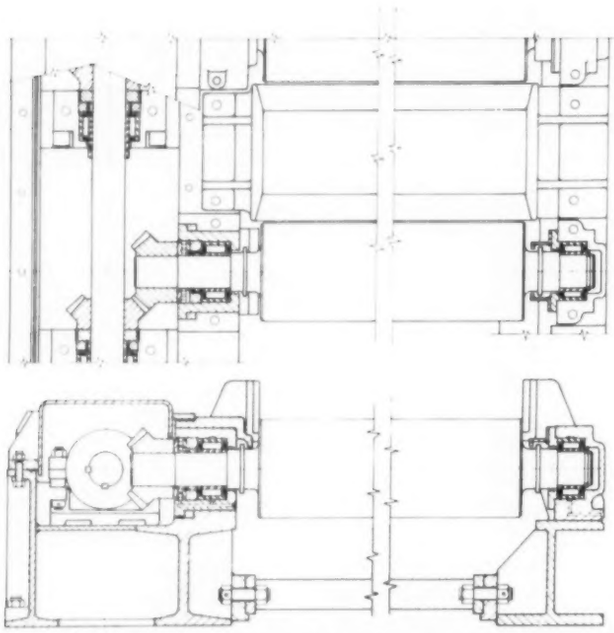


Figure 3 — A flat roller thrust bearing can be used to take the gear thrust when the roller is mounted on two straight cylindrical bearings.

required to operate under varying degrees of misalinement due to roller deflection from applied loads and warping due to temperature.

Although for many years straight cylindrical bearings were employed on both ends of table rollers with plain thrust washers for location, this design is no longer advocated by the manufacturers for heavy-duty tables, unless a flat roller thrust bearing is employed to take gear thrust. For light-duty tables, such as handling tables, this design is still preferred by some mills.

Bearing selection for table roller applications is far from being an exact science; particularly when related to expected bearing life. On light-duty tables such as run-out and handling tables, the roller body diameter is often selected based on required table speeds and strength considerations. The roller neck size is then selected to give good over-all design proportions. The neck size would then dictate the bearing bore size and very often regardless of the series or type bearing selected, the application would have considerably more theoretical capacity than actually required. In this case bearing selection should be based on bearing cost, over-all application cost and interchangeability.

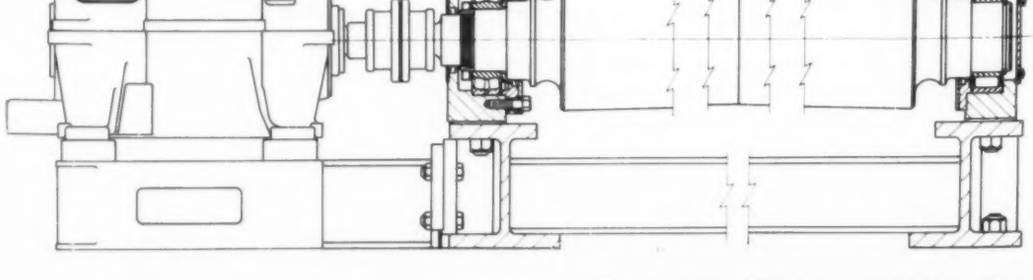
On heavy-duty main tables, such as furnace tables, delivery tables and reversing tables, roller neck size is often determined by allowable stresses and space limitations between and over bearing housings. In this case, bearing capacity consideration becomes critical. Since it has not been possible to develop accurately weighted load information, the conditions of speed and load based on maximum design conditions for a given table are considered. Also considered is the load to be carried on any two rollers or four bearings; a service factor of two is used.

Using this information and designing for a 20 to 25-year theoretical B-10 bearing life based on full time operation of the table, actually results in an average bearing life in the order of ten years. Obviously, bearing replacement rates will vary considerably from one mill to another; however, on heavy-duty tables replacement rates, from all causes, of three to five per cent per year are considered acceptable. No table bearing will operate under full load continuously: the development of a method where bearing capacity can be considered in selecting bearings for table service is desirable.

Figure 2 represents a cross-sectional view of a typical slab furnace table. Roller diameter is 16 in. and the bearing spacing is 5½ ft. Slab weight is approximately 20,000 lb. Due to heavy service on this table and relatively short bearing centers a 3-part, wide-series bearing was selected for the free end. A double-row, angular-contact bearing is shown on the drive side to maintain axial location of the roller. This particular application uses split cap housings. It will be noted that the outer race and roller assembly are located axially within the housing while the inner race is free to move axially due to ambient temperature changes, eliminating the necessity of floating the outer race which must be done when 1-part bearings are used. Although it is necessary to provide a means of lateral location of the separable roller assembly, the major reason for selection of this bearing type is to obtain maximum radial capacity in a given annulus while allowing for axial movement of the roller through the bearing. On this table axial movement due to ambient temperature change can approach ½ in.

Figure 3 shows a sectional and a plan view of intermediate lineshaft driven, 80-in. hot strip mill tables using 15-in. diameter rollers with a bearing center distance of approximately 8 ft. Roller spacing is 35 in.

Figure 4 — A 2-part cylindrical bearing was installed on the free end of the roller because of the heavy shock and heat conditions expected.



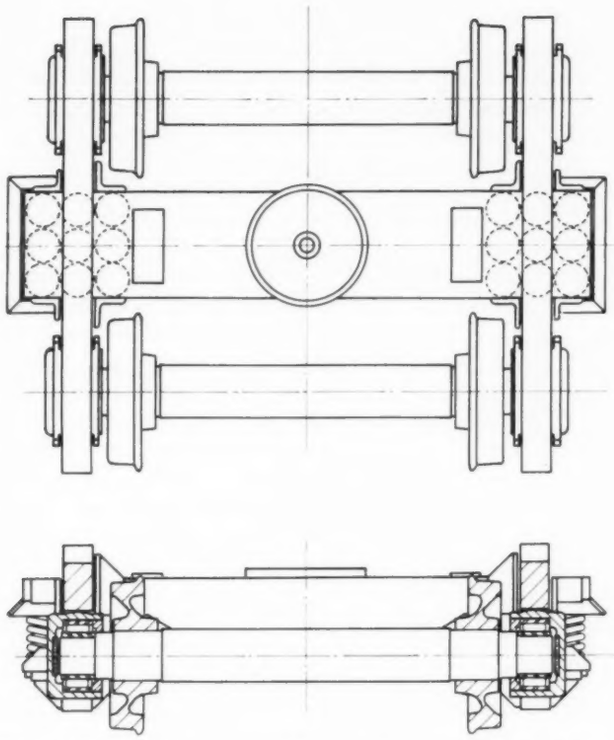


Figure 5 — The box assembly can be removed by raising the side frame and sliding the assembly off over the inner race.

Bearing housing OD was limited in order to allow for side guides of maximum size. To obtain maximum radial capacity in the limited bearing annulus, 3-part straight cylindrical bearings were selected for both ends of the table roller. Gear thrust is taken by means of a flat roller thrust bearing. The lineshaft is mounted on a 3-part straight cylindrical bearing with extended and notched inner races to allow for ease of disassembly for maintenance. Although the roller is located axially on the drive side, it is free to expand or contract through the bearing on the free or dead eye side. Bearing housings are one piece; however, ease of disassembly is facilitated by the use of a separable type bearing. This particular application has been in service for over two years with no bearing or gear failures reported.

Figure 4 shows a section of 56-in. hot strip mill and reversing mill approach, front and back tables. Maximum slab weight is approximately 40,000 lb, roller diameter 16 in., bearing center distance 6 ft-10 in. and roller spacing 27 in. Rollers are individually motor driven. Since shock and heat conditions are relatively severe on these tables, a 2-part straight cylindrical bearing was selected for the free side. This bearing differs from previous table applications shown in that the rollers are retained with the outer race between hardened and ground flanges. Since roller deflection can be expected, a metric series bearing is used with a relatively low L/D ratio. Roller crown and internal clearance are also tailored for this type of application. Axial location is provided by using a dual-purpose bearing on the drive side. The 2-part free-end bearing has a straight inner race allowing for lateral expansion of the roller through the bearing.

More industrial cars are equipped with straight cylindrical bearings than any other type. In selecting bearings for ingot cars a major consideration is the

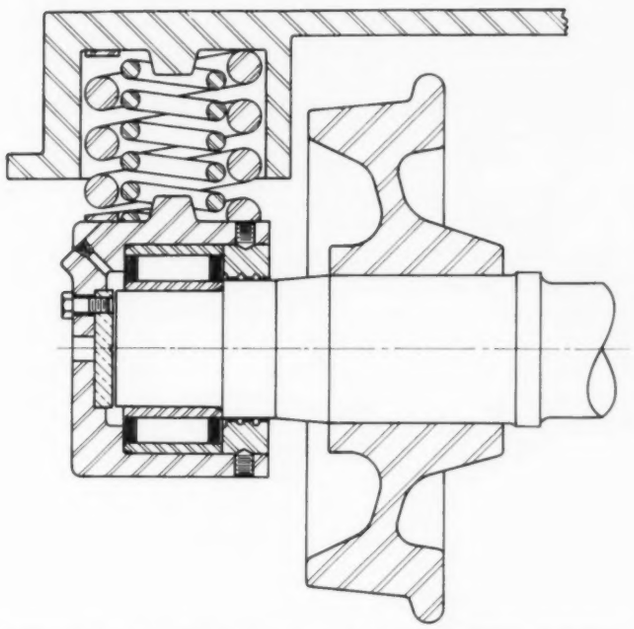


Figure 6 — Charging box assemblies are often designed for over-all simplicity and lowest initial cost.

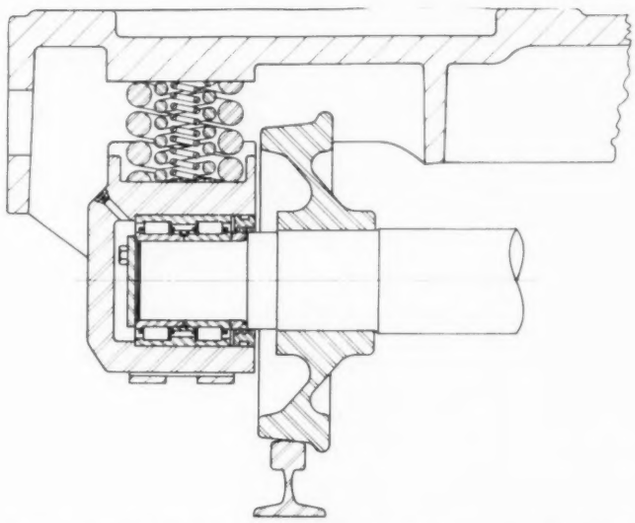


Figure 7 — The use of a flanged race eliminates the need for a separate thrust element.

type of loading. Since ingot stripping is most often done on the car, this is the condition where the bearings receive the greatest loading under shock conditions. Since cars are in a static condition during stripping, it follows that the greatest component of shock load is in a radial direction. This being the case and accepting the theory that a straight cylindrical bearing gives the greatest capacity for a given annulus, it would appear that a straight cylindrical bearing is the bearing to use particularly if OD space limitations are a factor. Generally in ingot car bearing selection, in addition to the weight of ingots, molds, stools and sprung weight of the car, a factor of 50 percent is applied for shock due to stripping. Ratings at car speeds of ten mph are generally used. Bearing selection for ingot and charging cars must also include a consideration of the axle stress at the wheel seat or point of maximum stress. A stress no higher than 10,000 psi for plain carbon steel axles is acceptable. This has been exceeded by using alloy steel axles. Selecting bearings on the basis of 6000-hr

average life results in an average service life of about ten years, based on actual mill service records of bearing replacements for all causes.

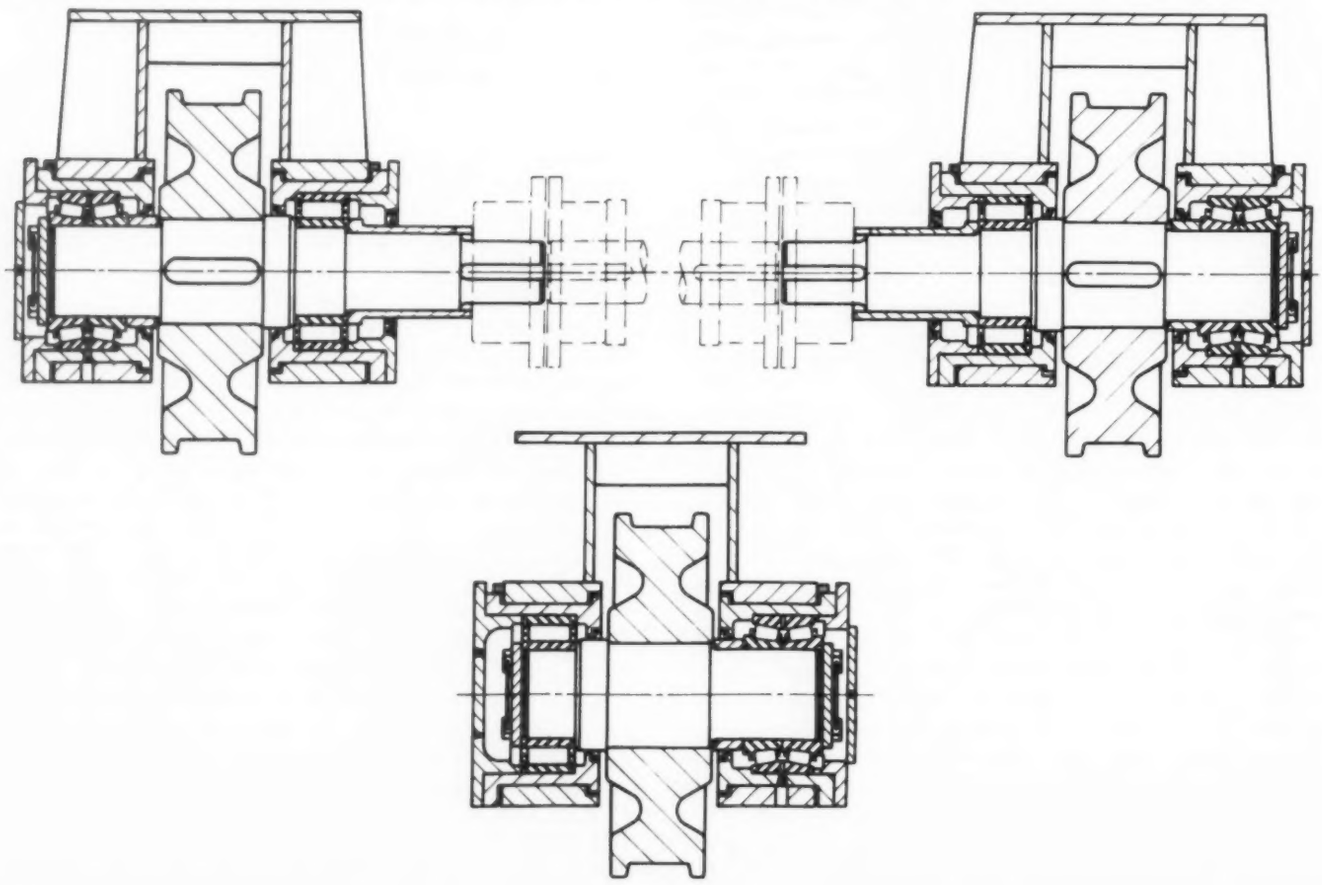
Figure 5 shows an axle section and plan view of a 4-wheel truck employed in 200-ton, 8-wheel ingot-mold car. This particular car employs bolster and spring plank construction. Bearings selected are 3-part bearings with extended length inner races to allow for lateral float of the bearing box. The bearing box OD is crowned to allow for alinement of the bearing and box in relation to the side frame. Lateral location of the axle is accomplished with bronze thrust blocks at the ends of the axle. The use of bronze thrust blocks may appear to be "horse and buggy engineering." However, this type of application is low in initial cost. From a maintenance standpoint, in the event of bearing damage from spills or failure, the side frame may be jacked-up and the entire box assembly slipped off over the inner race. Any one of the three bearing components may be replaced individually which is not possible with 1 and 2-part bearings.

Figure 6 shows a section through the wheel and axle assembly of a 4-wheel charging-box car. Although bearing loads on this type car are lower than those of ingot cars, bearing selection is based on the same considerations. This application is similar in design to the 8-wheel car, except that the bearing boxes are individually sprung. When individually sprung bearing boxes are employed it is necessary to use springs where the ends are ground square with the axis to facilitate good alinement of box and bearing. Excluding the need of selecting a bearing with adequate capacity, the major reasons for selection of a 3-part straight cylindrical bearing for this application would be the over-all simplicity of design and low initial cost, ability of the bearing to withstand shock loading and operate under dirty conditions and ease of maintenance.

Figure 7 is a section through the wheel and axle assembly of a 115-ton, 4-wheel, cast-body, ingot-mold car. This application employs a flanged race, double-row cylindrical bearing. The reason for selection of this type bearing is that the bearing allows for maximum radial capacity and at the same time takes axial location through the bearing flanges. By use of two rows of rollers, good load distribution is accomplished. Use of flanged races eliminates the need for external means of taking location. Disassembly is accomplished by removal of the inboard closure and slipping the box off the outer race. Bearing removal is accomplished by removing the locking plate and using a bearing puller to remove the bearing. Lateral float is controlled within the bearing. This type of bearing is now in ingot car service in both 4 and 8-wheel cars in a number of mills.

Overhead traveling cranes represent an important area for bearing applications in the steel industry. The application and selection of crane bearings has been given considerable study, and as a result AISE Standard No. 6 has been developed. This standard is presently being revised. The selection of bridge and trolley track wheel bearings using this standard is based on a minimum life of ten years, and is broken down into five classes from Class 0 to Class 4 of from 5000 to 40,000-hr life. Bearing size is then selected on the basis of box load. This figure is based on 75 percent of

Figure 8 — The lowest cost bearing available for a given service application is the shouldered end ring type.



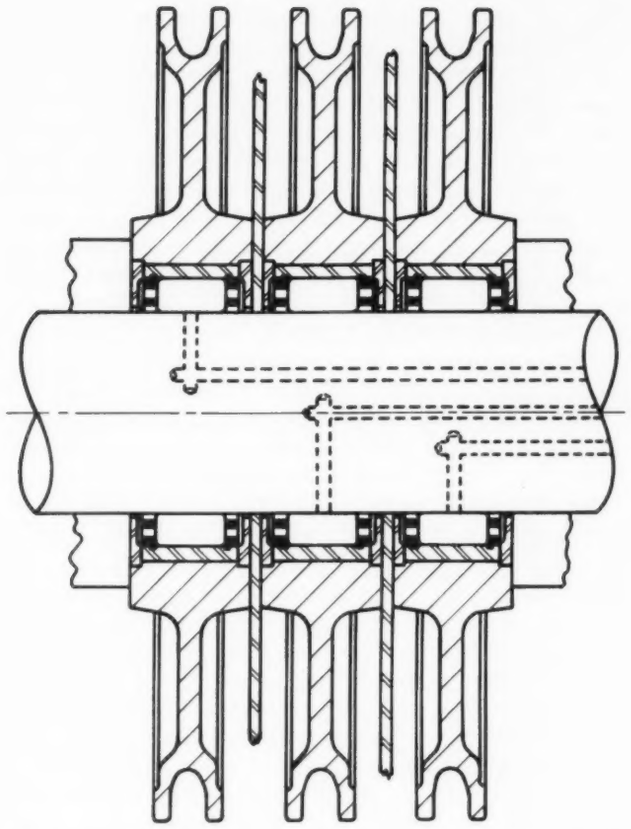


Figure 9 — A hardened and ground sheave pin is used with straight cylindrical bearings to maximum sheave capacity.

the maximum box load. Bearing bore size selection for this standard was made primarily on the basis of actual bearing capacity; except in those cases where the axle stress became the determining factor.

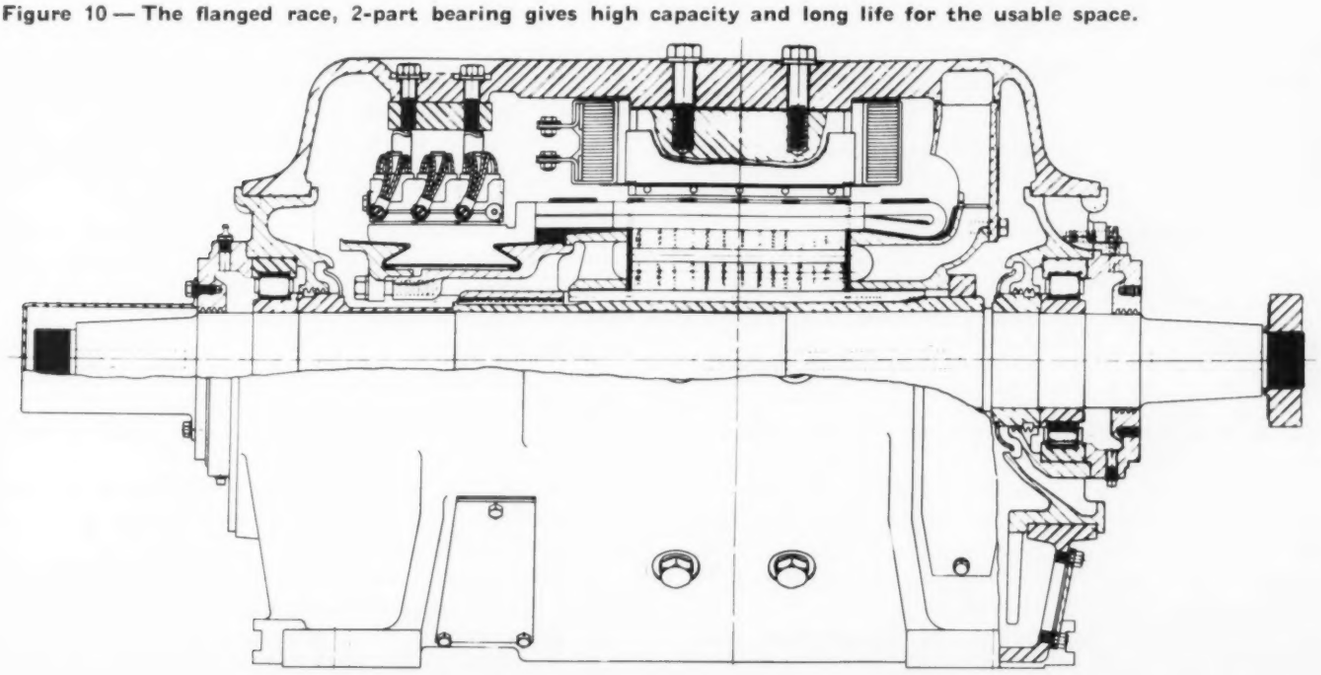
Figure 8 shows trolley track wheel assembly construction of both driver and idler axles. Box load is approximately 45,000 lb. Two-part straight cylindrical bearings were selected for the free side while double-row tapered bearings are used to locate the axle. The straight inner race employed on the free end allows the bearing to adjust laterally due to stack of tolerances in assembly and deflection under load. When selecting bearings for a given class service the selection of the shouldered end ring type bearing represents the lowest cost bearing available.

Straight cylindrical bearings have been employed on sheave blocks as shown in Figure 9. This section shows how a maximum amount of capacity may be packed into a small space. The bearings used are 1-part bearings without inner races, and the stationary pin must be hardened and ground. Lubrication is introduced through the pin. One of the major advantages of this arrangement is that sheaves and bearings may be easily replaced by simply withdrawing the pin. A disadvantage is that any failure of the bearing operating surfaces on the pin requires a completely new pin. This objection has been somewhat overcome by periodic indexing of the pin to present a new bearing surface in the load zone.

One of the oldest and most successful applications of straight cylindrical bearings in the steel industry is represented by the d-c mill motor. In the early 1920's 100 series motors, then plain bearing equipped, were modified and changed over to wound roller straight cylindrical bearings on both ends of the armature. Bronze thrust washers were used for location. This change worked out so well that when the 400-series motors were developed they were designed for both straight cylindrical bearings and plain bearings, and 300-series, wound-roller bearings were used with bronze thrust washers for location. In the middle 1940's the present AISE, 600-series d-c mill motor was developed, see Figure 10. This motor is available in frame sizes 602 through 624. In the selection of bearings for the 600-series motor the 1300-series, flanged-race bearing was selected because:

1. Earlier application of the straight cylindrical bearing had proved that this type bearing could withstand the loads encountered in mill service.

Figure 10 — The flanged race, 2-part bearing gives high capacity and long life for the usable space.



2. Lubrication was simplified and over-all maintenance costs were reduced. The flanged race, 2-part bearing shown in Figure 10 also offered the highest capacity and the longest life for the space available in a given frame.

Furthermore, by using a 2-part bearing, both the inner and outer races and the roller assembly could be located on both ends of the armature and in the housing. Selection of a flanged race bearing provided axial location of the armature and eliminated external means of taking location. Changes of armature length due to temperature change and to some degree critical control of tolerances are provided for by using a 2-part bearing and allowing for float between inner-race flanges. Mounting inner-race flanges inboard against the shaft shoulder backs up the flange, and at the same time allows for removal of the outer race and roller assembly without breaking press fits when disassembling the motor for armature repairs, etc. Thousands of the 600-series motors are in service with completely successful bearing operation.

The selection of the type and size of bearing for steel mill applications is not black magic; however, it is not an exact science. In design, consideration of theoretical loads and stress is not enough. The economics of original cost, subsequent maintenance costs, environmental conditions and skill of the people who maintain the equipment are equally important points to consider.

Discussion

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F. C. Kreitler: It may be of some historical interest to note that when the original d-c mill motor standardization was under consideration in the middle 1920's, some 60 per cent of the active AISE members wanted the motors designed to use either anti-friction or sleeve bearings. The first standardized motors were designed this way. The interest in sleeve bearings disappeared quickly. A check of records indicates that about 15 motors were made with sleeve bearings through 1928, and since then all standardized motors have been built with anti-friction bearings.

The author has given a number of reasons why the single-width cylindrical roller bearing was adopted as standard for the d-c mill motor. The bearing sizes in the 600-series motors were established by the shaft diameters required to keep stresses at a reasonable level at maximum starting torque with the minimum pinion diameter, rather than by bearing life considerations. Under these conditions the calculated fatigue life is long, and it might be thought unnecessary to use the single-width cylindrical roller bearing which has maximum radial capacity for a given section. Experience has shown that bearings with lower radial capacities have not been satisfactory, probably because of the extreme dynamic loading. As a result, a number of the older motors have been changed to the present standard bearing.

The shock and vibration to which these motors are subjected in steel mill service make it important that the outer race be clamped securely in the frame parts, and that the inner race be a tight fit on the shaft. Relative motion between the races and their mating parts causes fretting corrosion and wear. The use of cylindrical roller bearings having a double-ribbed outer race and a single-ribbed inner race assembled with the ribs inboard is very well suited to this type of motor. It permits axial location of the armature with considerable end play, and all relative axial motion between armature and frame due to temperature changes or impact thrust loads occurs between the inner and outer races with both races fixed. Other bearing arrangements which require a part of the bearing to move in its support have not been satisfactory under the operating conditions of the mill motor.

It is felt that the single-width cylindrical roller bearing now used in the 600-series motors is ideally suited for this application.

Charles F. Simmers: Use of roller bearings in crane sheaves has a definite advantage in the ease of removal of the sheave pin on ladle cranes where the pins are long and difficult to handle.

One of the most severe uses of roller bearings is on the journals of coke-quenching cars. In this application, the bearings are subject to heat from the hot coke, steam and water laden abrasive materials.

The AISE has performed an excellent job in establishing "hours of life" for bearing selection for steel mill cranes as per AISE Standard No. 6.

At this time it should be suggested and urged that a specification of this type be established for steel mill rolling equipment, as it is very difficult to write specifications for the purchase of such equipment without a basic specification.

F. R. Fielding: What are the advantages or disadvantages of solid rollers vs wound rollers? In what type of applications would split outer races be used rather than solid outer races?

A. G. Treiber: Does the author have some criteria governing the amount of allowable deflection in cylindrical roller bearings?

E. C. Peterson: A recently furnished 32-in. reversing billet mill was originally designed with tapered roller bearings on the drive side and straight cylindrical bearings on the outboard end of the table rollers. On the

lineshaft, tapered bearings were used to take the thrust with cylindrical rollers carrying the shaft. All bearings included in the original design were to be fitted with inner races.

However, a design used with success by the purchaser was adopted. The roller journals were removable, hardened, forged pins with straight cylindrical bearings mounted directly on them, with a bronze horseshoe collar to take the thrust. The lineshaft similarly was carried on straight cylindrical bearings with a bronze collar for thrust. This design was installed, has worked satisfactorily for years and has since been used on an additional installation with success. The argument given in its favor was simplicity of maintenance, for it is true that the bearings can be changed very easily with no need for assembling or disassembling tight fits.

American mill design has always leaned toward simplicity and ease of maintenance. It is quite possible to go too far in obtaining the best operating design and find that maintenance has been complicated unjustifiably. Ease of maintenance should not be ignored as a design consideration.

Andrew E. Cichelli: We at Bethlehem have just undertaken an intensive program surveying our bearing practices. It was discovered that a 62¢ bearing on a machine required 12 man-hours to replace, and in six months, the company suffered a loss of $1000 because of bearing repairs on this machine.

This is an extreme case, but it is felt that this problem was the responsibility of the builder and that the equipment builder should have considered the maintenance aspect, perhaps as importantly as anything else.

It was learned in this survey that many, many bearings are disposed of during repair periods if the maintenance people feel they have had enough service. Most believe it is better to throw them away, as a sound precautionary measure, than to chance breakdown during operation. This is done even though much life may remain in the bearing. The bearing manufacturers agree that this practice is widely followed, and that a program will have to be developed to educate our people in the handling, storage, application and examination procedure for these bearings. It is hoped that a concerted effort will produce a vastly improved bearing picture.

Philip H. Hutchinson: Wound roller bearings were used at first for tolerance control was relatively poor, sealing was even worse and lubrication was not very good. The wound roller bearing does a good job operating under these conditions, though it does not have the theoretical capacity of its solid roller counterpart. There are mills today which are using wound roller bearings and specifying wound roller bearings in their equipment. Generally, this is since the conditions described prevail. There are also economic factors to consider. With new, heavy-duty equipment the solid-roller bearing is being used.

Split outer races and the wound rollers grew together. The split outer race is used in applications where it is desired to present a new operating surface to the roller assembly, where the lubrication conditions are difficult, where loading is not as severe, and also where something rather inexpensive is needed, compared to a solid race with the same size bearing.

Particularly in steel mill applications, internal clearances and roller crown must be tailored for the intended use. The internal clearance and the roller crown of a given bearing as selected by an engineer is based on an over-all consideration of the load, speed and lubrication, under which the bearing might be expected to operate.

Roller crowning is an important factor, and it will allow for a reasonable degree of misalinement. This degree will vary by series and size of the bearing. Where severe deflection or misalinement is involved, there are self-alining bearings available.

It is not only the selection of the bearing based on capacity that is important. All these factors of maintenance, etc., are important, for the mill operator is concerned with cost.

Straight cylindrical bearings used with a bronze thrust block are still preferred by some people, and the bronze thrust block properly lubricated and maintained will do a good job. However, very often this is not the case and this is the reason that the anti-friction type of locating bearing is necessary on most new high-speed mills. ▲

Be Sure To Attend The Inspection Trip!

Armco Steel Corp.

Butler Works

Thursday, September 28

A Standardized Method for Rating Roller Bearing Load-Carrying Capacity

by E. C. DENNÉ, JR., Assistant Chief Engineer, SKF Industries, Inc., Philadelphia, Pa.

. . . . uniform bearing base speed and life ratings will permit the user to accurately determine the most economical bearing for any given application; however, after selection, proper lubrication and maintenance procedure are necessary to obtain rated life from any bearing . . . .

IT is as impossible to predetermine the life of an individual rolling contact bearing as it is to predetermine the life of one's next door neighbor. Bearings have lives even as people. Some die young; some live to a ripe old age. How, then, can bearings be selected to assure satisfactory performance?

LIFE EXPECTANCY

Bearing life is not based on wear, lubrication failure or operating temperature. For all practical purposes, even after prolonged use, roller bearings exhibit no wear. Even though improper lubrication may make a bearing unserviceable, satisfactory lubrication will preclude such failure. Present day demands for higher loads and speeds result in higher bearing temperatures, but this is no basis on which to predict bearing life.

When selected, mounted, protected, lubricated and otherwise handled properly, a bearing will operate satisfactorily until it fails from fatigue of the material. Fatigue, which is also referred to as flaking or spalling, appears initially as hairline fissures generally hidden below the contact surface of the rollers or raceways. These fissures develop into a spalled area on one of the load carrying surfaces. In the final analysis, fatigue is unavoidable. Fortunately, most bearings reach the scrap pile due to obsolescence of the equipment rather than from fatigue failure.

If a test is run with a large group (say 30) of apparently identical, single-row bearings under the same conditions of load, speed, etc., some life information can be determined. Record the number of revolutions each bearing rotates until fatigue is first noticed, as shown in column 2, Table I. A plot of these failures according to bearing serial number shows the scatter in bearing life, see Figure 1. The main reason for this dispersion is that the material is not homogeneous. Bearing life is dependent on weak points in the material. Even though the extent and location of these weak points is unpredictable, the test results can be dealt with statistically.

By replotting the failures in order of bearing life with the lives on the vertical axis and the failures, by percentage, on the horizontal axis, a curve is produced which is characteristic of any group of identical bearings run to failure under the same conditions, see Figure 2. This graph shows that 90 per cent (27 out of the test lot of 30) reached or exceeded a life which is about $\frac{1}{5}$ of the median life L_M. The median life is the life reached or exceeded by half of the bearings (15 bearings in this case). Although generally accepted and used, the concept that 90 per cent of all bearings tested exceed $\frac{1}{5}$ the median life does not always hold true since the curves obtained from many test series are similar but do not entirely conform in their general shape. It is exceptional for the maximum life attained to be more than four times the life L_M.

There is a difference between the characteristic failure dispersion of bearings, people and light bulbs. Man-made objects generally have a typical concave curve while human life produces a convex curve. A bearing is discarded when one part fails, and a light bulb when it is burned out. When a person has a failure of a part, such as a broken arm, the part is repaired and the person returns to service. Also, final inspection weeds out many short lived bearings or light bulbs while many humans die at birth. For these reasons, the general shape of the life dispersion curves for man-made objects and people differ.

Dispersion curves of bearing life expectancy have been obtained from extensive, time consuming tests using large series of identical bearings. From these tests it has been established that reliable yet economical bearing selection should be based on the life of the first 10 per cent of bearings failures, referred to as L_{10}. This means that in any bearing application there is the possibility that the bearing might fail before this life is obtained. However, if the basis of bearing selection is less than this L_{10}, the designer would be led to relatively large or heavy designs which would be completely uneconomical.

Consequently, the rating life is that number of

TABLE I
Test Statistics

Bearing Serial No. 1	Life million revolutions 2	Life million revolutions 3
1	3,200	3,200
2	5,100	
3	600	600
4	1,500	
5	14,600	1,300
6	1,300	
7	9,000	8,700
8	8,700	
9	5,800	3,900
10	3,900	
11	5,000	1,700
12	1,700	
13	13,500	4,200
14	4,200	
15	18,500	9,200
16	9,200	
17	9,500	5,000
18	5,000	
19	1,250	1,250
20	3,300	
21	15,000	6,300
22	6,300	
23	700	700
24	4,100	
25	10,800	10,800
26	17,300	
27	8,000	400
28	400	
29	2,700	2,700
30	4,500	

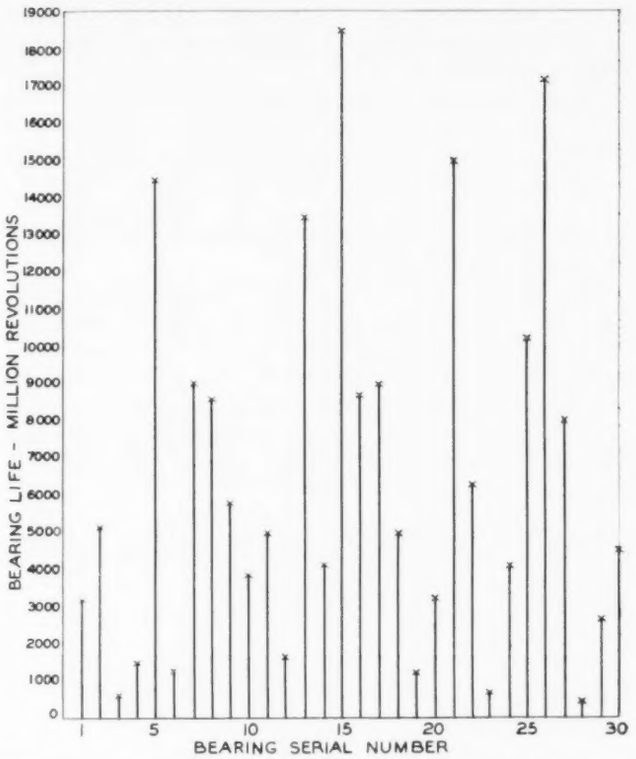


Figure 1 — Bearing life statistics are obtained by testing heavily loaded bearings at high speeds until failure occurs.

millions of revolutions (or hours at a constant speed) that 90 per cent of a group of bearings will complete or exceed before the first evidence of fatigue develops.

It is well established that bearing life decreases considerably as load increases or vice versa. To establish this relationship is a time consuming job. When it is considered that the life of a bearing in a normal application may be 30,000 hr (L_{10}) or that the last bearing to fail might live to approximately 600,000 hr, it would take about 70 years to complete the tests. Consequently, tests to determine the life-load relationship have been confined to relatively highly loaded bearings at high speeds permitting short calender life.

By running a large number of such tests, the following relationship, which is called the life formula, has been determined:

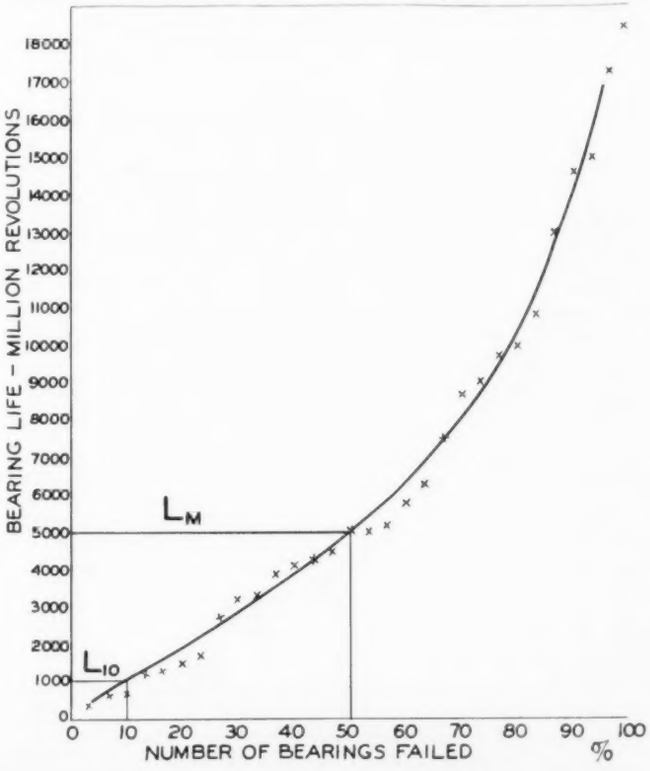
$$L = \left(\frac{C}{P}\right)^p$$

L = The bearing life in millions of revolutions when subjected to the bearing load P.
C = The basic dynamic load rating of the bearing: its carrying capacity for an L_{10} life of 1,000,000 revolutions.
P = The equivalent load carried by the bearing.
p = The exponent.

Since bearings do not operate at constant speeds or loads, it is necessary, for the purpose of calculating the expected life, to convert the load combination to a so-called "equivalent load." This is defined as that constant fixed radial load (for radial bearings) or thrust load (for thrust bearings) which, if applied to a bearing with rotating inner ring and stationary outer ring, would give the same life as that which the bearing will attain under the actual condition of load and rotation.

The exponent p in the life formula varies between three and four for roller bearings depending on whether point or line contact is obtained between the rollers and the bearing rings. For the sake of a uniform method of calculation, it is advantageous to use a mean value

Figure 2 — The median life L_M and the basic load rating L_{10} are indicated by replotting of statistical information.



of p for roller bearings equal to 10/3. The error introduced by this in the most common range of bearing usage is quite small.

The life formula for roller bearings is then:

$$L = \left(\frac{C}{P}\right)^{10/3}$$

for the ordinary range of bearing loads and within a reasonable degree of accuracy.

Thus, to predict the life of a roller bearing, the equivalent load and the capacity of the bearing to carry this load must be determined. If either of these quantities is ascertained incorrectly, the resulting life is affected accordingly. If the bearing manufacturer has calculated the basic load rating (C) of a bearing to be 100,000 and the equivalent load (P) is 50,000, the L_{10} life in millions of revolutions is,

$$L = \left(\frac{C}{P}\right)^{10/3} = \left(\frac{100{,}000}{50{,}000}\right)^{10/3} = (2)^{10/3} = 10:$$

$$\text{Life} = 10 \times 10^6 \text{ revolutions}$$

The same result could be obtained by using a higher bearing rating of 120,000 in conjunction with a recommended safety or application factor of 1.2.

$$L = \left(\frac{C}{P}\right)^{10/3} = \left(\frac{120{,}000}{1.2 \times 50{,}000}\right)^{10/3} = (2)^{10/3} = 10;$$

$$\text{Life} = 10 \times 10^6 \text{ revolutions}$$

However, if the safety factor is overlooked and the higher rating used, the life becomes:

$$L = \left(\frac{120{,}000}{50{,}000}\right)^{10/3} = 18.5; \text{ Life} = 18.5 \times 10^6 \text{ revolutions}$$

which may result in earlier bearing failure than predicted. If bearing load ratings are determined on a sound basis and loads calculated accurately, bearing life can be predicted to result in satisfactory bearing performance.

LOAD CARRYING CAPACITY

The ability of a roller bearing to carry load depends on the number and size of rollers, the geometry of the rollers and rings and the practical aspects associated with manufacturing tolerances and material. A simple comparison of bearing capacities can be made by multiplying the number, length and diameter (so-called NDL) of the rollers. It is important to remember that this does not give a basic capacity nor does it recognize various internal designs.

Subsequent to the NDL concept, bearing ratings were developed by extending limited empirical results to cover the manufacturers' full range of roller bearing types and sizes. In 1947, Acta Polytechnica[(1)]* was published which was the first tool that permitted the bearing engineer to extend accurately the laboratory life test results to cover other bearing types and sizes. By introducing the material shear stress at a critical depth below the surface, the volume of material subjected to stress and statistical methods, correlation between theory and test results was obtained. The Acta Polytechnica procedures were questioned by certain segments of the ball bearing industry, but the results were upheld by the United States Bureau of Standards. The Bureau based its conclusions on a review of laboratory test results furnished by all of the major ball bearing manufacturers who had cooperated in the interests of the industry. Some of the more important concepts on which roller bearing load carrying capacity is based are:

Bearing material—For roller bearings, prime consideration must be given to the material used. It is outside the scope of this article to get into the complex area of materials. It is sufficient to say that the method which will be described for calculating bearing capacity is based on current tests of roller bearings of good quality made of hardened roller bearing steel used by major bearing manufacturers. However, it must not be overlooked that if better bearing steel is discovered, the capacity of the bearing will improve accordingly and/or the total life dispersion of a group of bearings may be smaller which would mean bearing life could be predicted more closely.

Roller raceway contacts—As load is applied to a roller bearing, an area of support is developed between the rollers and raceways. To obtain the highest load rating, stress distribution along this roller raceway contact should be as even as possible. On the other hand, uneven stress distribution along this contact results in lower capacity and shorter bearing life.

Suppose that under no load a cylindrical roller has a line contact with a wider cylindrical bearing ring. If load is applied evenly, higher stresses will occur at the ends of the roller, see Figure 3. This is known as edge loading. Figure 3b shows the desirable even stress distribution that can be achieved by modifying the roller contour according to the dotted lines in Figure 3a. The same result could be obtained by making the roller raceway contact exactly the same length which is impossible to achieve from a practical standpoint, see Figure 3c.

This leaves the bearing designer with the problem of selecting the geometry that will permit the most effective use of the available contact area for the range of loads normally found in roller bearing applications. Instead of relieving (crowning or modifying) the rollers, the raceways can be modified to achieve the same results. These small differences in the relative shapes of contacting surfaces account for distinct differences in bearing capacity and life.

Similar results can be obtained in spherical roller bearings by using a different curvature between the roller and raceway, see Figure 4. The closeness between these curvatures is known as osculation. If the radius of the roller contour is only slightly smaller than the ring radius (left view, Figure 4), the contact will be a point under no load and, due to elastic deformation, a stretched out ellipse approaching a rectangle for high loads. The roller length is thus most effectively used in the load range normally encountered without detrimental edge loading. If the radius of the roller is made smaller (right view, Figure 4), the contact ellipse will be shorter and the roller length less effectively used. Three types of contact under no load conditions should be recognized:

1. Point contact refers to rollers and raceways so

* Numbers in parenthesis refer to Bibliography at end of article.

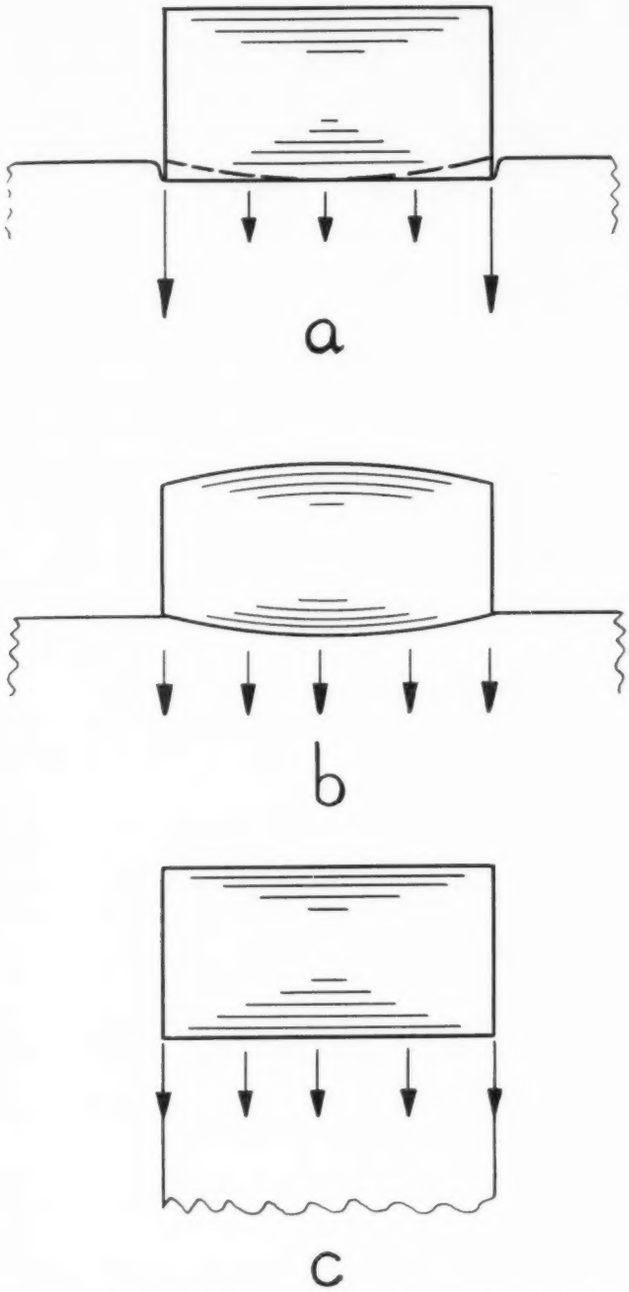


Figure 3 — Various types of loading are obtained by cylindrical roller contour modification.

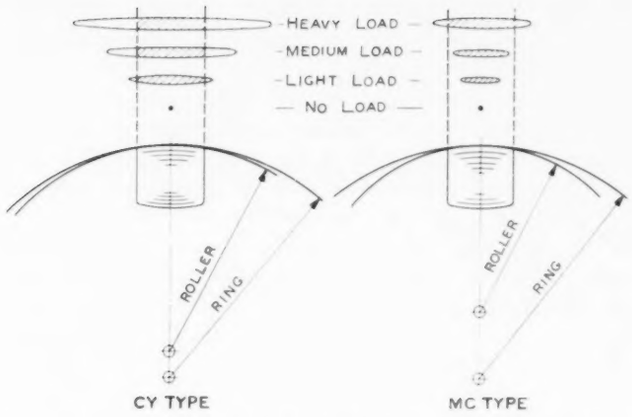


Figure 4 — Use of various roller and radius contours will affect the effective spherical roller length.

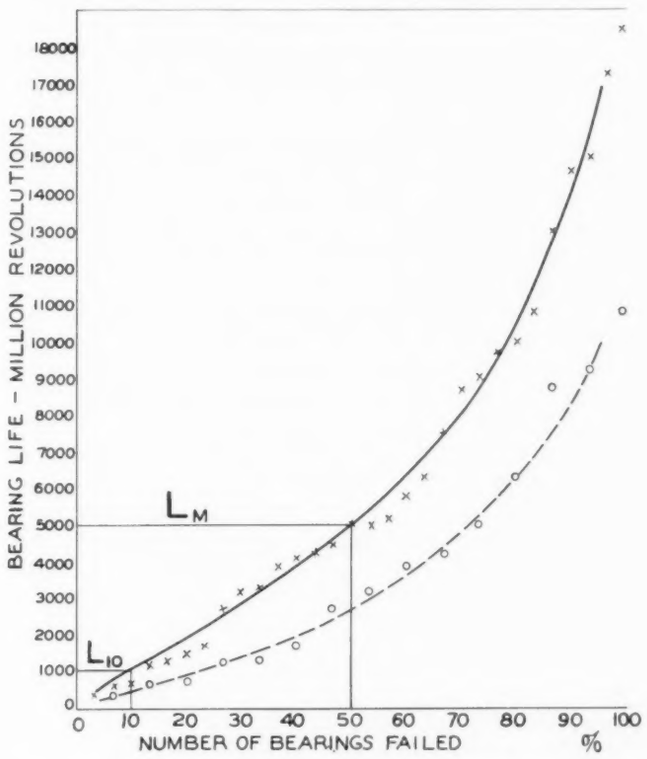


Figure 5 — The expected life of a double-row bearing as indicated by the composite curve is less than that of a single-row bearing.

formed that under no load and when in good alinement they contact at a point approximately at the middle of the rollers, and that under a bearing load of about one quarter of the basic load rating C, a contact ellipse at the most heavily loaded roller is formed whose length is equal to the length of its basic form. This type of contact precludes high stresses at the ends of the rollers and if designed correctly, results in high load ratings.

2. Line contact refers to rollers and raceways so formed that under no load and when in good alinement they contact along the full length of their basic form. In other words, if both bodies as seen in cross section possess the same curvature and contact each other in a line while in an unloaded state, it is termed line contact. As load is applied, the line of contact is transformed into a rectangular or trapezoidal area according to the design of the bearing. This type of contact results in edge loading. Because of this condition, bearings with line contact have a lower relative load rating than bearings with other types of contact.

3. Modified line contact refers to such departure from the basic form of the rollers and/or ring raceways toward their ends that under a bearing load of about one half of the basic load rating C, the material stress at the ends of the contact of the most heavily loaded roller with the ring is approximately the same as in the rest of this contact. This type of contact results in high load ratings.

Multiple-row bearings—Contrary to what might be expected, the number of rows of rollers in any one bearing does not increase the load rating of the bearing

directly, for a 2-row bearing does not have double the rating of a single-row bearing nor does a 4-row bearing have four times the rating.

With reference to the results of the test previously described, see Table I, assume the first two bearings to be one double-row bearing, the next two a double-row bearing, etc. Note the life of each double-row bearing as the lowest life of the pair (column 3, Table 1), for if one row fails, the bearing has failed. If these lives are plotted in order of bearing life the same way the single-row lives were plotted (Figure 2), a curve is produced which shows lower life for the combination as shown by the dashed line in Figure 5. The solid line is the curve of single-row lives which is the same as Figure 2.

It might be noted from Table I that a different combination of the single-row bearings might produce a curve nearly equal to the single-row lives. However, it is never equal since in all cases the lower life of the pair chosen would be decisive. Of course, such ideal pairing could not be manufactured or inspected into the bearing.

Roller length—As the volume of material under stress increases with the number of rows of rollers, it also increases with the length of the rollers. Since life is affected by the volume of material under stress and the nonhomogeneous nature of the material (weak points), the probability of weak points increases as the rollers are lengthened. A longer roller increases the capacity just as if it was considered to be a 2-row instead of a single-row bearing on the same basis as the increase in capacity just discussed for multiple-row bearings. At the same time, good bearing design dictates that the length of the roller be kept within reasonable limits with respect to the diameter. It is evident that the longer the roller, the harder it is to get ideal stress distribution along the length. At the same time, relatively long rollers are difficult to keep alined resulting in detrimental roller skewing.

Number of rollers—The number of rollers influences bearing capacity in two ways; first by the load on each roller and second by the number of contact cycles to which the loaded surfaces are subjected during one revolution of the inner ring.

If the number of rollers is increased, the load per roller is reduced permitting an increase in bearing capacity. Thus, if the number of contact cycles is constant, the bearing capacity is directly proportional to the number of rollers.

On the other hand, increasing the number of rollers increases the number of contact cycles per revolution. The life in millions of stress cycles is equal to the number of stress cycles per revolution times the life in millions of revolutions, or $N = \mu L$. Substituting the life expression $L = (C/P)^p$ into this equation, it is seen that for the same load per roller, the bearing capacity is inversely proportional to the p root of the number of rollers or $C = P\,(N/\mu)^{1/p}$.

Combining these two influences, roller bearing capacity is proportional to the number of rollers (Z) to an exponent less than one or $Z/Z^{1/p} = Z^{1-1/p}$.

Roller diameter—The larger the roller diameter, the higher the capacity. It must be recognized that there is an interrelation between roller diameter, practical bearing ring thickness, and number of rollers per row, i.e., for a given bearing section (bore to OD), the larger the roller diameter, the smaller the ring thickness and the fewer the rollers that will fit this particular pitch diameter. The bearing designer must be alert to the best compromise among these variables to obtain optimum capacity.

BASIC LOAD RATING

Based on the concepts, the expression for the basic load rating (C) of roller bearing is:

$$C = f_c\,(i\,l_{effective}\cos\alpha)^{7/9}\,(Z)^{3/4}\,(D)^{29/27}$$

C = The basic load rating for roller bearings used in the life formula $L = (C/P)^{10/3}$. C represents that constant stationary radial load which a group of apparently identical roller bearings with stationary outer rings can endure for a rating life of 1,000,000 revolutions of the inner ring.

f_c = A factor which depends on the exact geometrical shape of the load carrying surfaces of the rollers and rings, the accuracy of the bearing parts, the material and the units used. Values of f_c may be obtained from Tables II and III. The parameter $D\cos\alpha/d_m$ is determined from the geometry of the bearing where D = mean roller diameter, α = bearing contact angle and d_m = bearing pitch diameter which is normally midway between the bearing bore and the OD. Table III describes various types of bearings and roller raceway contacts. Although this designates the column to use in Table II, it must be recognized that all design variations cannot be covered adequately. Bearings made by reputable manufacturers must be expected to have a lower f_c/f value than shown in column a, Table II, if, under load, a local stress concentration is present in the roller contact. This may be the case for poor roller guiding, edge loading or low osculation, and f_c/f values higher than those shown in column a may be used if even stress distribution over the whole roller length is automatically assured. At the present state of the art, no bearing type has demonstrated an f_c/f value greater than those listed in column k. These f_c/f values do not take into account misalinement of nonself-alining type bearings which reduces the carrying capacity due to edge loading. The contacts used in major types of roller bearings manufactured by one of the bearing manufacturing companies permit using the f_c/f values shown in Table IV.

i = Number of rows of rollers in any one bearing.

$l_{effective}$ = The effective length of contact between one roller and that ring where the contact is the shortest (over-all roller length minus roller chamfers, or minus grinding undercuts). For estimating, considering roller corners only, the effective roller length is 95 per cent of the nominal roller length. Grinding undercuts in the rings may reduce the effective length considerably.

α = contact angle of the bearing equals the angle between the line of action of the roller resultant load and a plane perpendicular to the bearing axis. Cylindrical roller bearings have a zero contact angle. Tapered and spherical roller bearings generally have contact angles between 10 and 15 degrees but are less for rela-

TABLE II
Geometrical Factors*

$\frac{D \cos \alpha}{d_m}$	Values for f_c/f					
	j	h	b	a	g	k
0.01	0.061	0.069	0.077	0.083	0.089	0.095
0.02	0.072	0.081	0.090	0.097	0.104	0.111
0.03	0.078	0.088	0.099	0.106	0.113	0.120
0.04	0.083	0.094	0.105	0.113	0.120	0.128
0.05	0.087	0.099	0.110	0.118	0.126	0.134
0.06	0.091	0.102	0.114	0.123	0.131	0.139
0.07	0.093	0.105	0.118	0.126	0.135	0.144
0.08	0.096	0.108	0.121	0.130	0.138	0.147
0.09	0.098	0.110	0.123	0.132	0.141	0.150
0.10	0.099	0.112	0.125	0.134	0.143	0.152
0.12	0.102	0.115	0.128	0.138	0.147	0.156
0.14	0.103	0.117	0.130	0.140	0.149	0.159
0.16	0.104	0.118	0.131	0.141	0.151	0.161
0.18	0.105	0.118	0.132	0.142	0.151	0.161
0.20	0.105	0.118	0.132	0.142	0.151	0.161
0.22	0.104	0.117	0.131	0.141	0.150	0.160
0.24	0.103	0.116	0.130	0.140	0.149	0.159
0.26	0.102	0.115	0.128	0.138	0.147	0.156
0.28	0.100	0.113	0.126	0.136	0.145	0.154
0.30	0.099	0.112	0.124	0.134	0.143	0.152

$$f_c = \frac{f_c}{f} \times f$$

* A recommended value of the factor f based on current tests of roller bearings of good quality, hardened roller bearing steel is: f = 49,500 when lb and in. units are used; f = 56.2 when kg and mm units are used.

tively thin sectioned bearings and more for bearings designed to carry more thrust than radial load.

Z = Number of rollers per row. This may be estimated for bearings with cages by dividing the bearing pitch diameter by 1.25 times the mean roller diameter $d_m/1.25$ D. For bearings without cages, divide the pitch diameter by the mean roller diameter d_m/D. For estimating, the bearing pitch diameter may be assumed to be midway between the bearing bore and the OD.

D = The roller diameter (the mean diameter for tapered rollers). For estimating, the roller diameter is approximately half the bearing section height: (OD − bore)/4.

SAMPLE CALCULATION

To show how this method is used, the capacity of spherical roller bearing 22,340 C is determined. The properties of this bearing as described in the general catalog are as follows:

1. Double row with spherical outer ring, modified line contact between rollers and both rings, symmetrical rollers accurately guided by a separate, axially floating guide ring.
2. D = Roller diameter = 2.205 in.
3. d_m = Bearing pitch diameter = 12.327 in.
4. α = Contact angle, = 12 degrees −15 min.
5. i = Number of rows of rollers = 2
6. $l_{effective}$ = Effective roller length = 2.000 in.
7. Z = Number of rollers per row = 15

From the above, the f_c factor can be determined by referring to Tables II and III.

$$\frac{D \cos \alpha}{d_m} = \frac{(2.205)\ (\cos 12 \text{ degree} - 15 \text{ min})}{12.327} = 0.175$$

From Table III, column g covers the specific require-

TABLE III
Type of Bearing

Item		f_c/f Column No.
1	Cylindrical roller bearings with line contact between rollers and both rings, the rollers not accurately guided.	j
2	Cylindrical roller bearings with line contact between rollers and both rings, the rollers accurately guided by a machined cage or by uninterrupted guide surfaces at each end of the rollers, both of these surfaces associated with one of the bearing rings.	h
3	Tapered roller bearings with line contact between rollers and both rings, the rollers accurately guided by one integral rib.	h
4	Cylindrical roller bearings with line contact between rollers and one ring and point contact with the other, the rollers accurately guided by a machined cage or by uninterrupted guide surfaces at each end of the rollers, both of these surfaces associated with one of the bearing rings.	b
5	Tapered roller bearings with line contact between rollers and one ring and point contact with the other, the rollers accurately guided by one integral rib.	b
6	Self-alining roller bearings with spherical outer ring, line contact between rollers and the inner ring, and point contact with the outer ring, the rollers accurately guided by one or two integral ribs.	b
7	Cylindrical roller bearings with modified line contact between rollers and both rings, the rollers guided by a cage or by two snap rings, or one snap ring and one integral rib.	b
8	Self-alining roller bearings with spherical inner ring, modified line contact between rollers and both rings, symmetrical rollers guided by a cage.	a
9	Tapered roller bearings with modified line contact between rollers and both rings, the rollers accurately guided by one integral rib.	g
10	Double-row self-alining roller bearings with spherical outer ring, modified line contact between rollers and both rings, symmetrical rollers accurately guided by a separate axially floating guide ring.	g
11	Cylindrical roller bearings with modified line contact between rollers and both rings, the rollers accurately guided by uninterrupted surfaces at each end of the rollers, both of these surfaces associated with one of the bearing rings. (When the rollers are longer than 2.3 times their diameter, use column b.)	k

TABLE IV
Contacts Used

Roller Bearing Types	f_c/f Column no.
1. Spherical roller bearing series	
230	b
231	b
232	b
230 C	g
231 C	g
222 C	g
232 C	g
223 C	g
2. Cylindrical roller bearing series	
NN 30 K	k
N2	k
NU 2	k
NJ 2	k
N3	k
NU 3	k
NJ 3	k
N4	k
NU 4	k
NJ 4	k
3. Tapered roller bearings	
Bearings with rollers not crowned	h
Bearings with rollers crowned	g

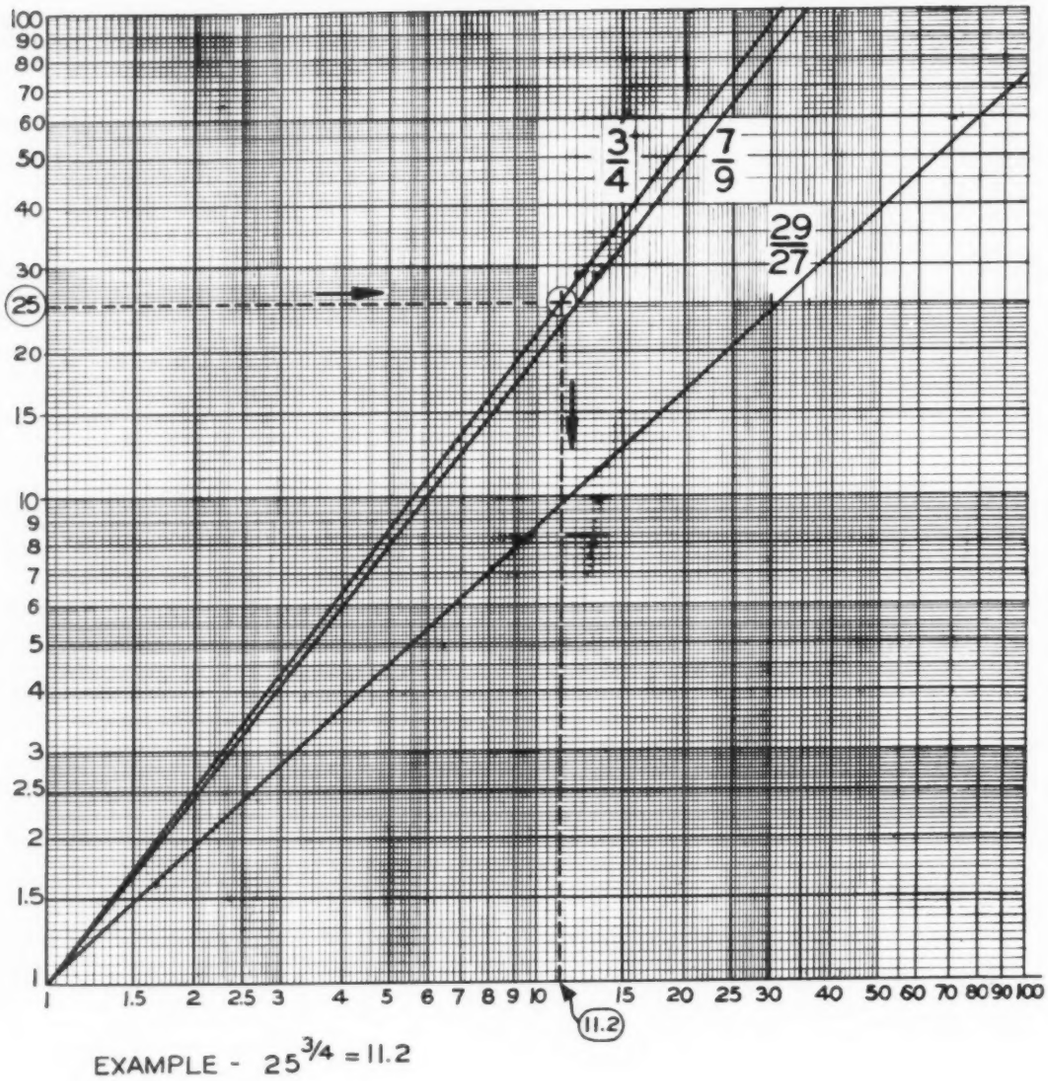


Figure 6 — The values of numbers raised to fractional powers are easily determined from the graph.

ments of this bearing design. From Table II:

$$f_e/f = 0.151$$

then: $f_e = f_e/f \times f = (0.151)\ (49{,}500) = 7470$. (see lower part of Table II for recommended f values). Therefore:

$$C = f_e\ (il_{effective} \cos \alpha)^{7/9}\ (Z)^{3/4}\ (D)^{29/27}$$

$$C = 7470\ (2 \times 2.000 \times \cos 12 \text{ degrees} - 15 \text{ min})^{7/9}\ (15)^{3/4}\ (2.205)^{29/27}$$

$$C = (7470)\ (2.88)\ (7.62)\ (2.34) = 383{,}000 \text{ lb} = \text{basic load rating}$$

This is the catalog capacity of bearing 22,340 C.

The power functions may be determined quickly from the graph, Figure 6.

Now then, if this bearing is to be used under a radial load of 75,000 lb with the inner ring rotation at a constant speed of 100 rpm, what prediction can be made concerning its L_{10} life in revolutions and hours?

$$L_{10} = \left(\frac{C}{P}\right)^{10/3} = \left(\frac{383{,}000}{75{,}000}\right)^{10/3} = (5.1)^{10/3}$$

$$L_{10} = 230{,}000{,}000 \text{ revolutions}$$

or

$$L_{10} = \frac{230 \times 10^6 \text{ revolutions}}{100 \text{ rpm} \times 60 \text{ min per hr}} = 38{,}000 \text{ hr}$$

The life in millions of revolutions or hours may be determined from the nomogram, see Figure 7.

SUMMARY

By now it should be realized that predicting roller bearing life is not an exact science. Based on limited laboratory testing and general experience, each bearing manufacturer has developed his own methods to rate bearings and predict bearing life. That is why the ratings published by each manufacturer have varied considerably more than the differences between seemingly identical bearings would permit.

Recognizing the confusion, in 1945 the AFBMA (Anti-Friction Bearing Manufacturers' Association) started an active study of developing a uniform and consistent method of evaluating load ratings based on the best information available. This resulted in the AFBMA, "Standard Method of Evaluating Load Ratings of Roller Bearings," published in March, 1956 (revised December, 1957) and the ASA (American Standards Association), "Load Ratings for Ball and Roller Bearings," approved in January, 1959. Most parts of the methods discussed are included in these two standards. It would seem that the ASA standard should be the desired uniform basis for rating bearings. Unfortunately, this is not the case since it is not used

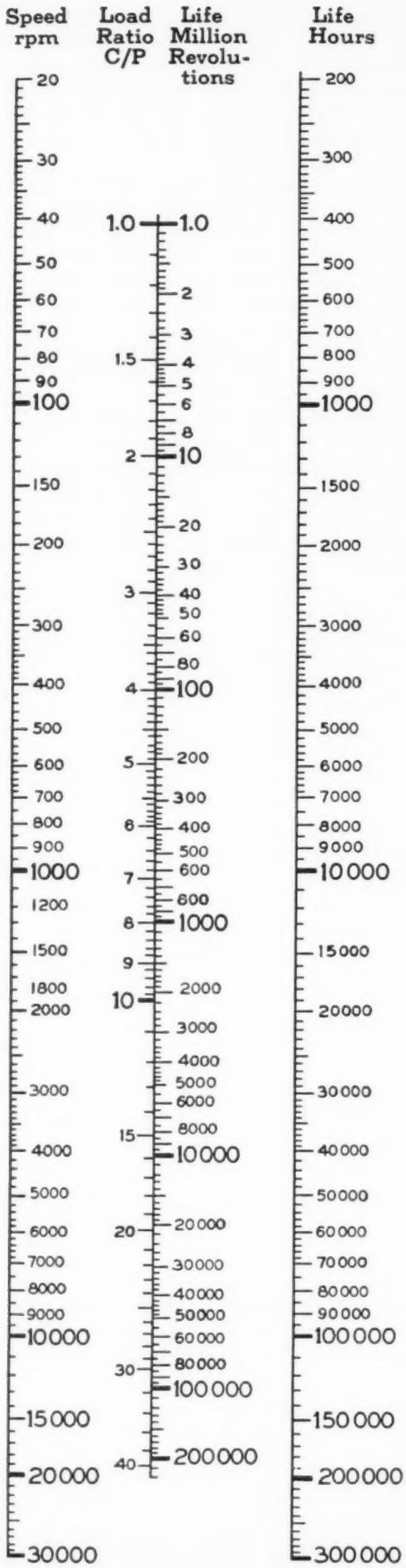


Figure 7 — The life values obtained are expected to be exceeded by 90 per cent of the bearings, and the bearing median life is five times that indicated.

by all manufacturers. If the user would request ratings according to the standard, much of the confusion would be eliminated.

Here, then, is a standard method for rating roller bearings and predicting bearing life. This method represents the consensus of the industry. Only the diligent study of bearing performance both by users and manufacturers will prove the worth of this standard in its present form and point the way toward needed refinements for even better correlation between theory and practice.

BIBLIOGRAPHY

1. "Acta Polytechnica," by G. Lundberg and A. Palmgren, No. 7, 1947.
2. "Acta Polytechnica," by G. Lundberg and A. Palmgren, No. 96, 1952.

Discussion

PRESENTED BY

M. E. OTTERBEIN, Assistant Chief Engineer, Hyatt Bearing Div., General Motors Corp., Harrison, N. J.

H. E. KAYE, Chief Engineer, Rollway Bearing Co., Inc., Syracuse, N. Y.

WALTER FISHER, Chief Engineer, Bantam Bearing Div., The Torrington Co., South Bend, Ind.

S. W. WECKSTEIN, Chief Engineer, Industrial Div., The Timken Roller Bearing Co., Canton, Ohio

E. C. DENNÉ, JR., Assistant Chief Engineer, SKF Industries, Inc., Philadelphia, Pa.

M. E. Otterbein: It is true, as the author points out, that the various methods of rating roller bearings has resulted in some confusion. However, it is felt that this confusion lies in the area of the life basis rather than how the load rating was obtained. So it is doubtful if the standardized formula is necessary or desirable.

There are some generally undesirable features: The formula sets a rating wholly dependent on the bearing dimensions without regard to quality. This means that the highest quality aircraft precision bearing has the same rating as a standard quality bearing if the general design, in both bearings are the same.

Since the rating is a function of the number and size of the rollers, the formula automatically assigns a high rating to a bearing where these parameters are high. Thus, there is no regard to other important bearing dimensions, i.e., the rib width, separator section size and wall thickness of the races.

Although the formula is a "standard," there is considerable latitude open on selecting the column for the f_c factor. This, indeed, is stated or at least inferred in the AFBMA standards. The difference of these factors across the table is some 50 per cent.

The AFBMA standards could have been confined to the providing of a definition of life and a standard life basis plus an approximate formula which would serve as a rough guide for bearing ratings. In this connection it must be kept in mind, especially in steel mill work, that some application factors are necessary

over and above the catalog rating, which is set up for ideal conditions.

The AFBMA has done an excellent job for the bearing customer and for the bearing industry in establishing dimensional standards. It is felt that the same excellent job will be done eventually on bearing load ratings.

H. E. Kaye: The basic idea of this formula is a good one and industry should recognize that this work was done primarily in its behalf, because as the author has pointed out, all the bearing companies in the past worked with a different basis and it made it rather confusing to the customer to arrive at a common basis from which to evaluate bearings.

This type of work also has been done on the cylindrical thrust bearings. A formula for this bearing has been adopted, which is roughly the same as the basic formula for the rating of cylindrical radial bearings, rating the bearing on 1,000,000 revolutions on a B-10 basis.

The basic formula for the rating of bearings does not relieve the customer of the problem of reviewing the bearing application, the structure of the bearing, the material from which the bearing is fabricated and other pertinent points which go into making up the bearing to be used for any given application.

Walter Fisher: The past ten years of action by the Annular Bearing Engineers Committees and Roller Bearing Engineers Committees has resulted in considerable standardization of bearing envelope dimensions, shaft and housing fitting practice and terminology. All of these developments have simplified the selection and application of ball and roller bearings.

One of the most significant gains made was in the standardization of the base to which all bearings are rated. Nearly all manufacturers catalog rate their bearings to the same base speed and predictable life. This enables the user to make direct rating comparisons.

The basic concepts set forth in the capacity formula cited by the author are accepted by the bearing industry but there is not complete agreement on the geometrical factors of various bearing types. On this point, several of the major bearing manufacturers disagree.

Further testing of bearings on industry wide basis is required to develop a more universal rating formula and evaluation of geometrical factors.

Predicting roller bearing life is not an exact science. In the final analysis the experience of the bearing manufacturer and the user must prevail.

It is significant that two or more bearing manufacturers working with the same given operating data will nearly always come up with same size bearing and recommendation for a given bearing type.

Bearing maintenance, lubrication and other environmental factors are most influential in obtaining long bearing life. Those users of bearings with a good knowledge of installation and maintenance procedures obtain maximum performance for bearing dollar cost. The value of this is seen in all of industry, and it is particularly true in the tough heavily loaded applications as well as those where environmental conditions are not conducive to long bearing life. Much has been said and written on the subject of bearing care but more needs to be done. It cannot be over-emphasized, continued education on the part of bearing manufacturers and users will pay extra dividends.

S. W. Weckstein: We, as well as Rollway, Torrington and Hyatt, agree that there is such a thing as a bearing formula that might be used. However, we cannot accept all of the terms as given in the present formula as submitted in the author's paper.

The formula as presented is without question based on tests made on cylindrical and spherical roller bearings. If tests have been made on tapered roller bearings they must have been made on tapered roller bearings of the ISO standard sizes, which closely approximate boundary dimensions of ball bearings and cylindrical roller bearing as known on the European continent. We cannot agree with some of the criteria that have been accepted in the formula for rating these roller bearings as published by the AFBMA and the ASA.

The Timken Roller Bearing Co. voted against adopting this as a standard formula. We were overruled and it was adopted. Since that time, some of the other bearing manufacturers have objected to it, and the standard use of this formula for the rating of spherical roller bearings has been withdrawn.

There is general agreement with the arrangement of the formula, but not with the exponents. There is very little difference in some of the exponents and they could be compromised. However, the f_e factor cannot be accepted. It is felt that the tapered roller bearing is not the same problem as the cylindrical roller bearing. Entirely different reactions occur in the tapered roller bearing than in the cylindrical roller bearing, and these reactions and developments within the bearing itself must be taken into consideration.

We also agree with the statement made by Mr. Otterbein, we cannot accept an f_c factor as given in the present formula, because we are constantly making bearings of different materials. Bearings are made of steel, and depending on the quality of steel, and the new types of steel that are coming into use, the f_c and other factors are going to be entirely different.

The Bureau of Standards did all their work on ball bearings. There has been nothing done on tapered roller bearings or other types of roller bearings.

In making ratings on bearings, an attempt is made to compare results in the field, and it cannot be agreed that a 4-row tapered roller bearing acts as the multi-row cylindrical roller bearing. There are certain reactions within the bearing itself. In other words, taking advantage of preloading bearings or setting them loose causes reactions within the bearing. Due to these thrust reactions which occur within the bearing the load within the bearing is properly distributed.

It is felt that the adoption of this standard formula should be refused, but there should be some sort of a formula for the user to use. We are continually working on this subject, making hundreds upon hundreds of tests, and we hope sometime in the not too distant future to be able to present the results of the work which we have done in order to clarify some of the things in this field. Until that is done, it is felt that the user should not be asked to request ratings according to this formula. If the user insists on them he is going to have problems and he is not going to obtain what he desires.

E. C. Denné, Jr.: There has been disagreement

among some bearing manufacturers concerning this method.

A standard accepted and used by all bearing manufacturers is needed. The majority of of manufacturers have approved the described methods as a standard.

The statements made concerning the Bureau of Standards refer to ball bearings only.

On the method of rating bearings having more than one row of rollers, we, of course, are in disagreement with Mr. Weckstein. Regardless of the actions within the bearing to get even load distribution (reference "Recent Developments in Roll Neck Bearing Design and Mounting," 1959 proceeding, AISE p. 393) the fact remains that as soon as one weak point in the bearing fails, the whole bearing has failed. It would be ideal if all parts failed at the same time, but this is not the case. There is a wide dispersion in the life of each row of a multiple-row bearing (i.e., work roll bearings). How then can a 2-row bearing have twice the load rating or twice the life of a single-row bearing?

Mr. Weckstein has also cautioned the user that to follow the methods outlined in the present standard "will get him into trouble and that he is not going to get what he is looking for." How can one get into trouble using load ratings figured according to this formula when, in every case, the AFBMA ratings for tapered roller bearings are lower than the ratings published by Mr. Weckstein's company?

Mr. Weckstein also said, "Since that time, some of the other bearing manufacturers have objected to it, and the standard use of this formula for the rating of spherical roller bearings has been withdrawn." The standard does cover the method for rating spherical roller bearings. However, with regard to numerical values for f_c factors it is not as specific as for some types of cylindrical and tapered roller bearings. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, October 30, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Forged Steel Rolls," by A. A. Bradd, Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

Redmont Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, October 10, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Ultrasonic Testing of Steel Mill Equipment," by William Tait, Metallurgical Dept., Dominion Foundries and Steel, Limited, Hamilton, Ontario, Canada

Sheraton Hotel, 715 Delaware Ave., Buffalo, N. Y.

CANTON SECTION

CLEVELAND SECTION

PITTSBURGH SECTION

YOUNGSTOWN SECTION

Wednesday, October 25, 1961—Inspection Trip (Afternoon—Buses will load at Packard Music Hall, northwest side, Warren, Ohio, from 1:30 to 3 P.M.)

Inspection Trip: Republic Steel Corp.'s Warren, Ohio Hot Strip Mill

Social hour, Warner Hotel, Warren, Ohio, 4:30 to 6:00 P.M.
Dinner 6:30 P.M., Meeting 7:30 P.M., Packard Music Hall, Warren, Ohio

Talks covering the new hot strip mill by: Leonard Larson, Chief Engineer in Charge of Flat Rolled Products, Republic Steel Corp., Cleveland, Ohio; Stephen Wheeler, Assistant Chief Engineer, Republic Steel Corp., Warren, Ohio; and I. G. Orellana, Head, Measurement and Control, Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

Dinner and Meeting—Packard Music Hall, Warren, Ohio

COLORADO SECTION

Tuesday, October 17, 1961—Dinner 7:00 P.M., Meeting 8:00 P.M.

"Quality Control Liaison," by Ray Warfield, Senior Product Supervisor, Quality Control Dept., The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Tuesday, October 10, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Users of High-Purity Oxygen for Steel Plants," by J. S. Steele, Linde Co., Div. of Union Carbide Corp.

Engineering Society of Detroit, 100 Farnsworth, Detroit, Mich.

LOS ANGELES SECTION

Monday, October 9, 1961—Social Hour 6:15 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Production Planning and Mill Scheduling," by Ivan Rebert, Superintendent, Production Planning, Kaiser Steel Corp., Fontana, Calif.

Michael's Restaurant, Telegraph Road and Washington Blvd., Los Angeles, Calif.

ST. LOUIS SECTION

Wednesday, October 25, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"A-C Crane Control," by J. A. Halvorson, Electrical Engineer, Bridge & Crane Control Section, Cutler-Hammer, Inc., Milwaukee, Wis.

Elks Club, Granite City, Ill.

UTAH SECTION

Monday, October 9, 1961—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.
Joint Meeting with AIEE

"Management—A New Profession Gaining Rank," by G. A. Jedenoff, General Superintendent, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Grandview Cafe, Provo, Utah

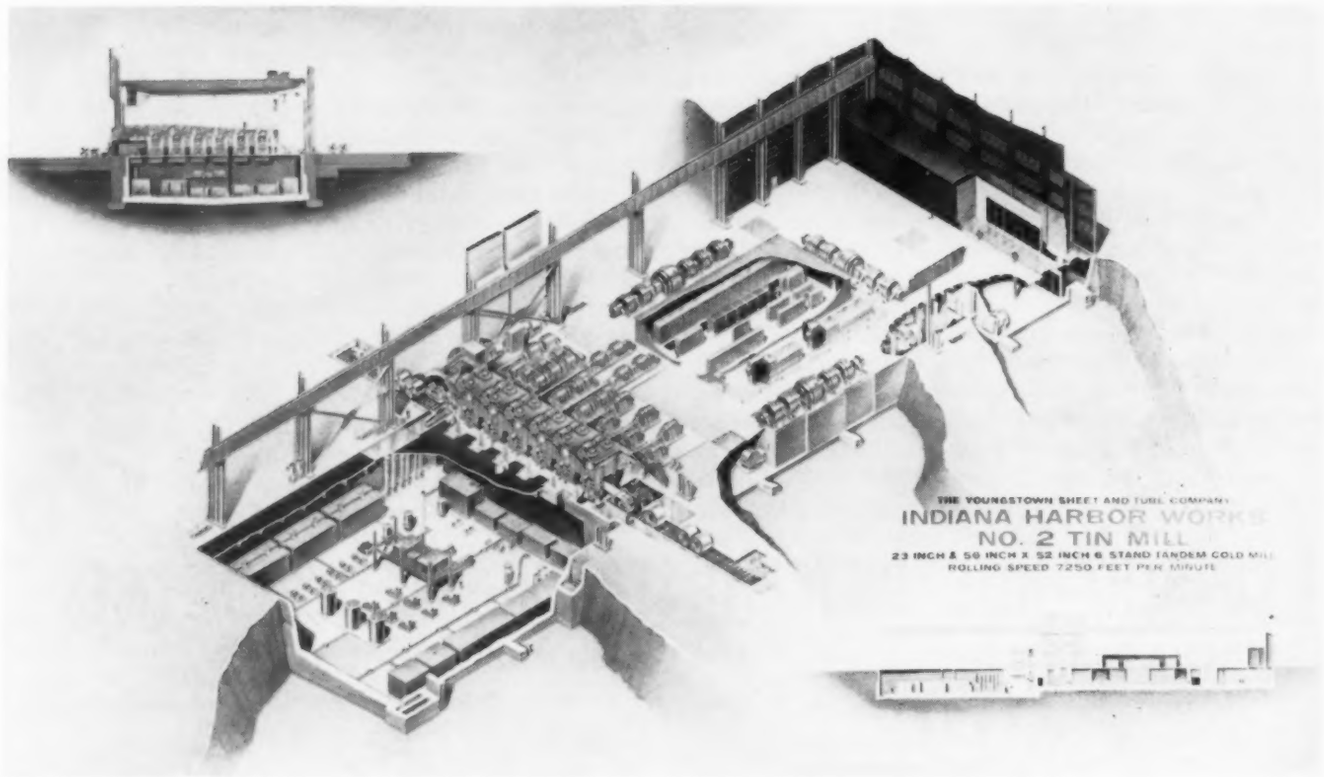


Figure 1 — Artist's conception of 6-stand mill.

Youngstown Completes Three Projects at Indiana Harbor

THE Youngstown Sheet and Tube Co. unveiled recently the world's first high-speed six-stand cold reduction mill, a new continuous annealing line, and a new hot-dip galvanizing line at the Indiana Harbor Works.

The first two are the latest installations designed for improved quality control and production of tin plate at the company's modern No. 2 tin mill.

Other new facilities include construction of an 87-oven coke battery, and a 300-ft extension of the ore dock to provide additional raw material handling and storage space.

SIX-STAND COLD MILL

The 52-in., six-stand mill, the largest and fastest in the steel industry for rolling of steel tin-plate strip, started production in March, 1961. Its rated maximum speed is 7250 fpm. It can be brought up to maximum speed in 14 sec and stopped in seven sec.

There were three objectives in selecting six stands:

1. Ability to run at higher speeds. (Mill has already broken current speed barrier with production runs over 6000 fpm.)
2. Mill can take thicker bands off hot strip mill with resultant hot band economies.
3. Sixth stand permits rolling of thinner tin-plate gages than possible on 5-stand mill.

Automatic gage control is accomplished by variable-voltage screws on stands No. 1 and 2 and tension control on stands No. 5 and 6. The knowledge for this control will be received from X-ray gages mounted after stands No. 1 and No. 6 and load cells.

All stands are equipped with load cells mounted in each housing and tensiometers mounted between each stand.

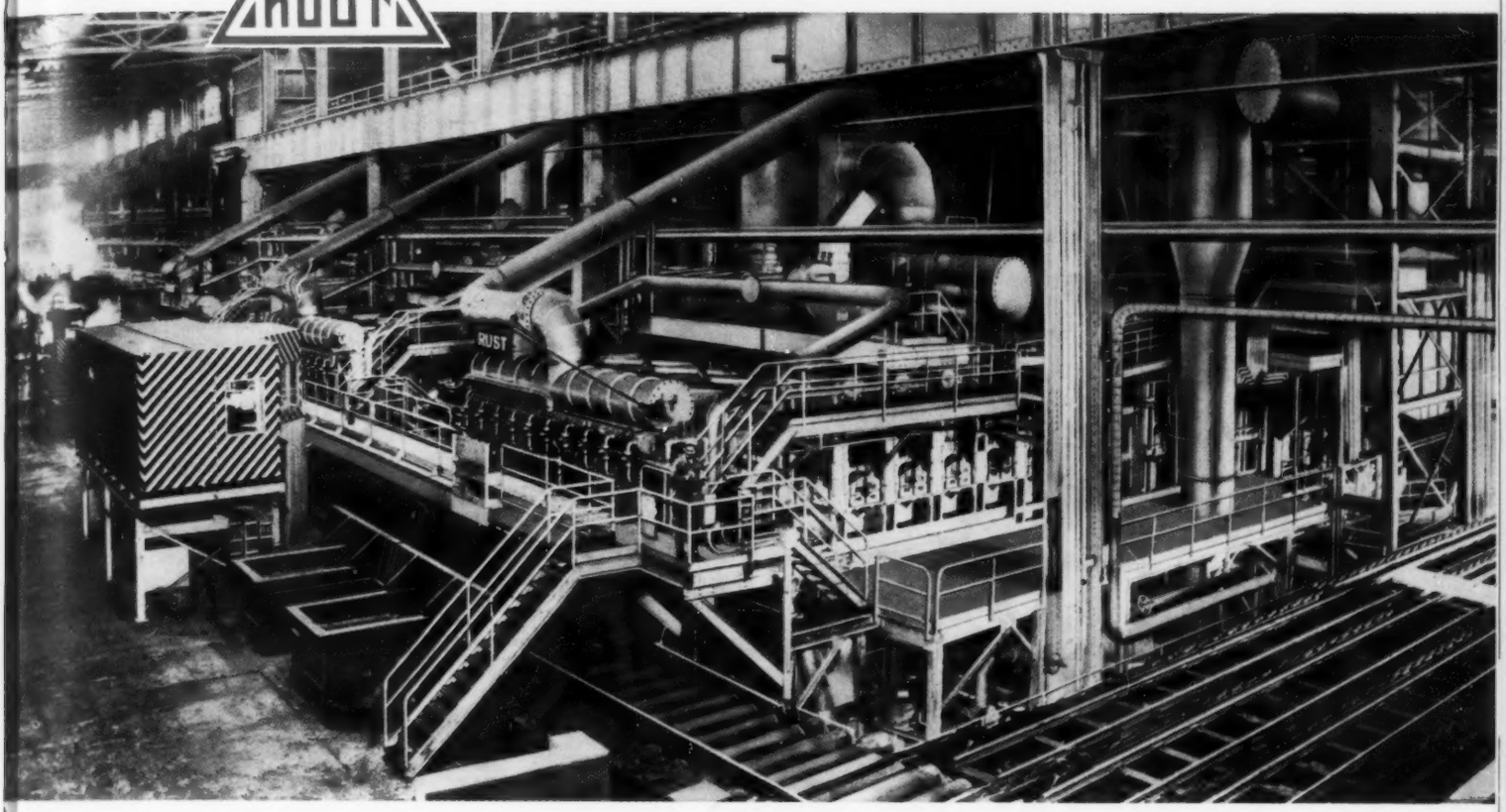
Data logging equipment is provided to record a complete history of each coil rolled.

Coils 46 in. wide x 80-in. OD x 62,100 lb with a 16-in. ID are rolled on this mill. Minimum delivery gage is 0.0035 in.

The mill is designed with a top delivery speed of 7250 fpm. The stands are spaced on 14 ft-0 in. centers and use up to 23½-in. diameter x 52-in. work rolls and 56-in. diameter x 51-in. backup rolls. Anti-friction roller bearings are used on the work rolls and oil-film bearings are used on the backup rolls.

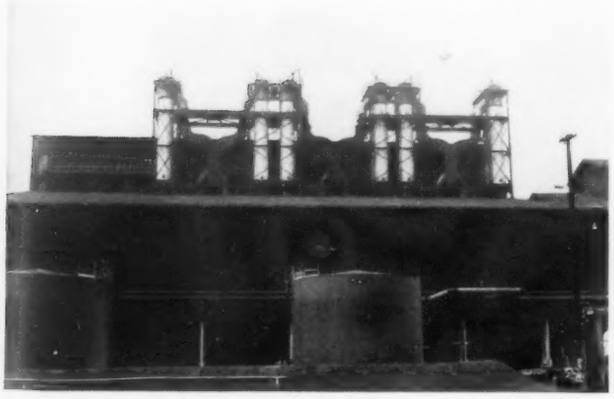
Screwdowns on stands No. 1 and No. 2 are controlled by two 100-hp adjustable voltage motors per stand. The screwdowns for the remaining stands use two 75-hp motors per stand.

Pioneers in Furnace Design



World's Largest Hot Strip Mill Furnaces
designed and constructed by RUST
for Bethlehem Steel Company

Five-zone furnaces at the 56" strip mill, Sparrows Point Plant, Bethlehem Steel Company, are each capable of reheating more tons of slabs per hour than any other existing furnaces.



12 Rust-Escher recuperators serve the three reheating furnaces.

NEW DESIGN FEATURES INCLUDE:

- *Unusual instrumentation*
- *Work platform arrangement*
- *Flue arrangement*
- *Skid pipe and supports*
- *Rust-Escher metallic recuperators*

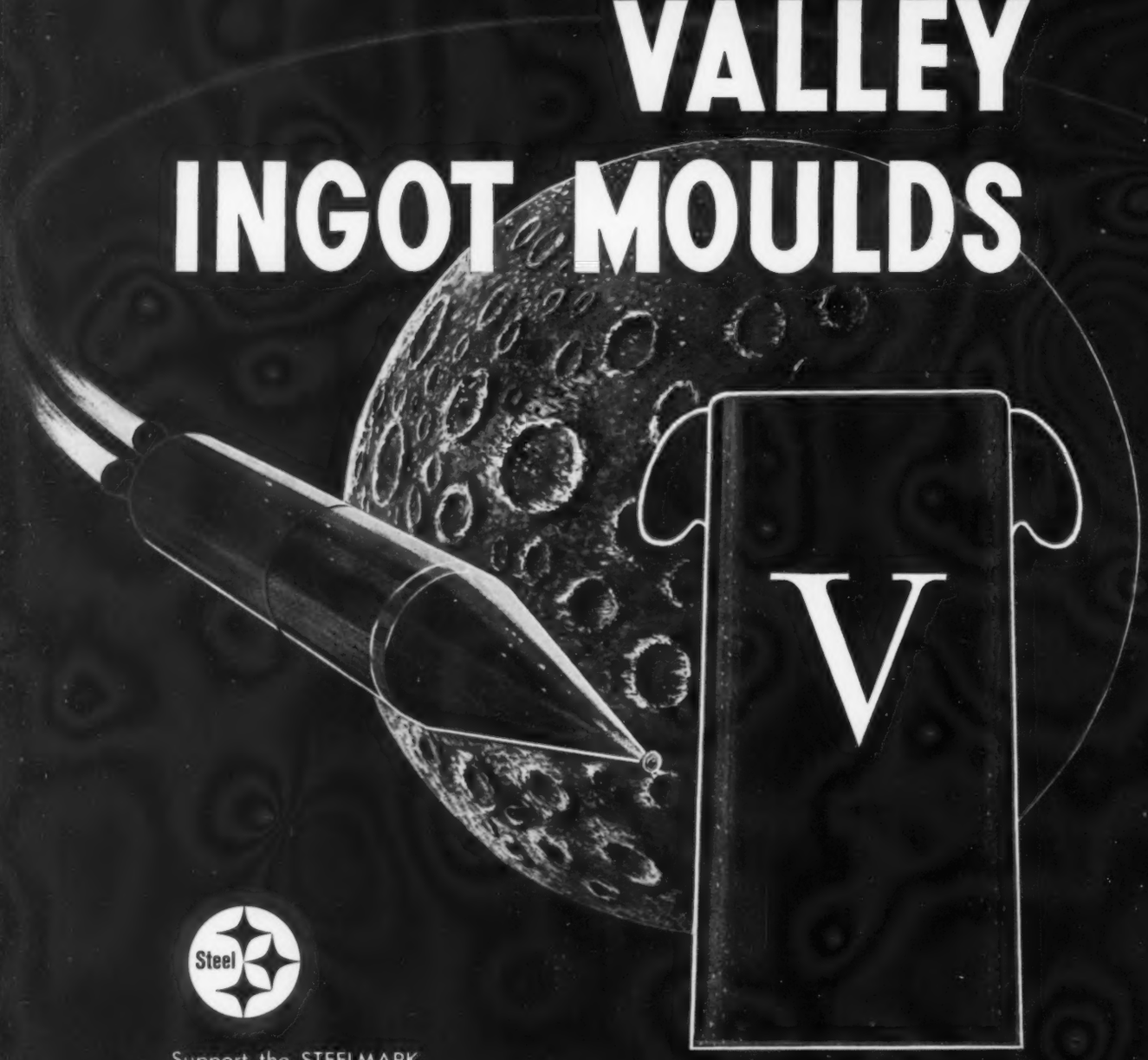
Consult us about *your* requirements in the melting, reheating or heat treating fields.

RUST FURNACE COMPANY
930 Fort Duquesne Boulevard • Pittsburgh 22, Pa.

Associated Companies: STEIN & ATKINSON, Richmond, Surrey, England • STEIN ET ROUBAIX, Paris, Liege and Genoa

For over 75 years steel has been poured into Valley Moulds, and now the new metals... used in space .... will also be poured into

VALLEY INGOT MOULDS



Steel

Support the STEELMARK

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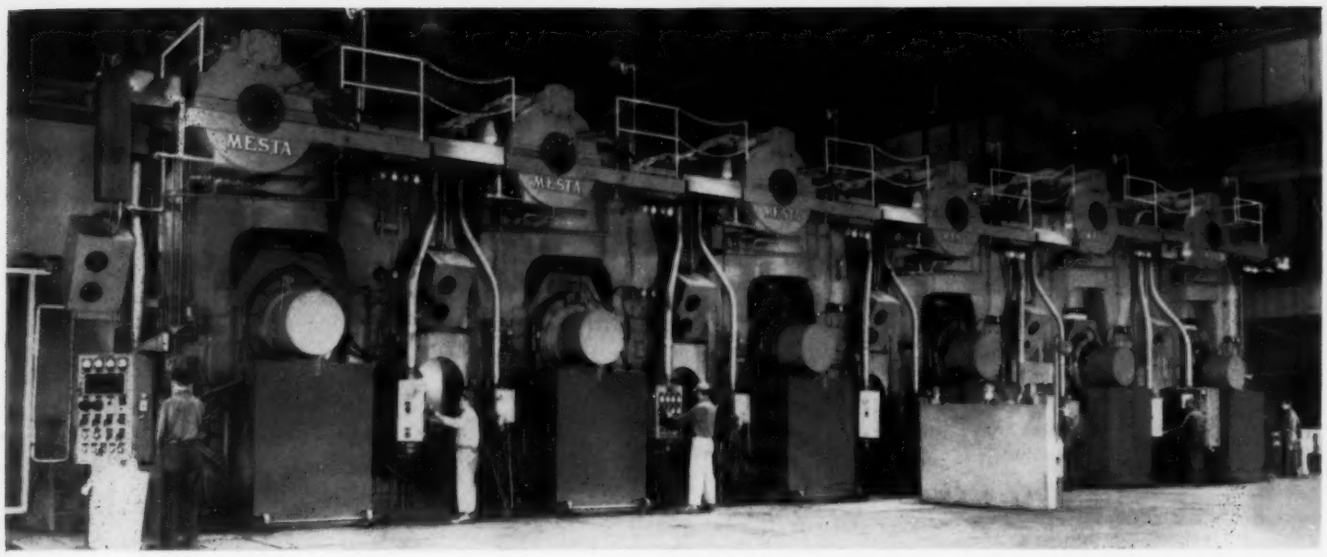


Figure 2 — The 6-stand cold reducing mill is driven by motors delivering 34,900 hp.

TABLE I

Stand	Work roll: Nominal size	Work roll: Material	Backup roll: Nominal diam in. type	Drive motor: No. motors	Drive motor: Total hp	Drive motor: Rpm	Gear ratio	Speeds, based on 23½ in. diam: Minimum	Speeds, based on 23½ in. diam: Maximum
1	21½	Cast iron	56 solid	2—1500	3000	125/375	1.363	555	1680
2	21½	Cast iron	56 solid	2—2500	5000	212/520	1.438	900	2250
3	23	Forged steel	56 solid	2—2500	5000	212/520	1:1	1300	3200
4	23	Forged steel	56 sleeve	4—1500	6000	255/637	1.108:1	1750	4330
5	23	Forged steel	56 sleeve	4—1500	6000	255/637	1.1515:1	2380	5925
6	23½	Forged steel	56 sleeve	6—1250	7500	300/635	1.1863:1	3420	7250
T.R.	16½	Forged steel		4—600	2400	200/1000	1.768:1		

Total 24 = 34,900

Individual stand drive information is shown in Table I.

Three motor-generator sets as noted in Table II serve the mill drive motors:

Auxiliary equipment serving the mill consists of two individual solution systems with a standby third system for roll coolant; four circulating oil systems and three hydraulic systems.

Rolling oils and discharge waters are pumped to a waste treatment system to be cleaned prior to discharge to the main sewers.

Ventilation air is supplied by an up-draft system to the main mill drives and motor-generator sets.

A separate roll rack with chuck handling equipment has been provided to strip and build up work rolls.

The mill, drives, motor control, roll racks, roll storage, roll build-up and grinding, are located on the main floor area of a new building 125 ft wide x 615 ft long attached to the No. 2 tin mill, two auxiliary buildings, one 567 x 125 ft wide, another 480 x 120 ft wide, provide coil storage space.

Lubrication, solution, hydraulic and ventilating systems are located in basements in this same building.

The main mill building is served by a 75-ton crane. Two cranes are installed in the auxiliary coil storage buildings.

A main 138-kva substation was installed with this mill to receive incoming power for the district facilities.

A recirculating cooling water system for the six-stand mill tied in with cooling water requirements for the continuous annealing line is located outside the main building.

TABLE II

	Motor-generator set No. 1	Motor-generator set No. 2	Motor-generator set No. 3
Motor			
Hp	12,000	12,000	15,000
Rpm	514	514	514
No. 1 generator			
Kw	1—2400	2—2000	3—2000
Serves	No. 1 stand	No. 3 stand	No. 6 stand
No. 2 generator			
Kw	3—2000	2—2400	2—2400
Serves	No. 2 stand and tension reel	No. 4 stand	No. 5 stand

CONTINUOUS HOT-DIP GALVANIZING LINE

Production of Youngstown's new galvanized sheet started in May, 1961. This sendzimir type galvanizing line furnishes product in either sheet or coil form.

The line is 862 ft-6 in. long with the leveling, coiling and shearing section doubled back under the cooling, coating and furnace section. Approximately one half mile of strip is in transit during operation. The strip width ranges from 20 to 62 in. wide with gages from 30 to 10. Maximum coil size is 72-in. OD x 48,000 lb. Maximum sheet

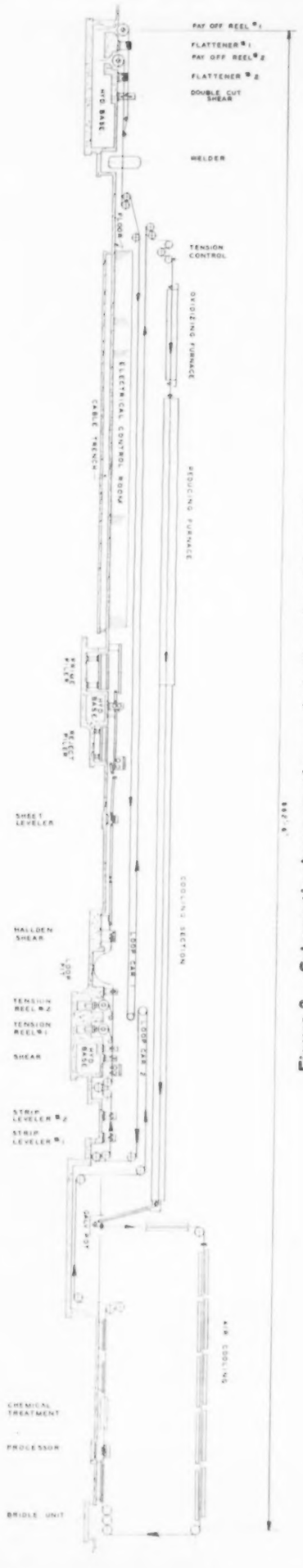


Figure 3 — Schematic shows continuous hot-dip galvanizing unit.

length is 22 ft-0 in. Maximum processing speed is 400 fpm. Coating thickness varies from 0.65 to 2.75 ounces per sq ft.

Coils are delivered to the entry section of the line from the cold reduction mill or pickle line.

The entry section consists of two uncoilers; a shear; a welder and a looping car to provide strip storage for welding time in order that a continuous operation may be maintained through the processing section. The entry section also contains contact thickness gages and an X-ray thickness gage to insure that an exact gage is being coated and to provide a record of all product.

The processing section consists of:

1. Oxidizing furnace.
2. Reducing furnace with a cooling section.
3. Coating pot and rig.
4. Cooling section.
5. Pull through leveler.
6. Chemical treatment tanks.

The oxidizing furnace serves the purpose of: (1) burning off all rolling oils and undesired materials from the strip to provide a clean surface; (2) oxidizing the strip surface; and (3) preheating the strip to 750 F.

After leaving the oxidizing furnace, the strip has a characteristic blue-gray appearance and enters the reducing furnace. The strip is heated by natural gas-fired radiant tubes, to annealing temperature (up to 1750 F, depending upon product), in a reducing atmosphere of dissociated anhydrous ammonia which prepares the strip surface for coating. After attaining the annealing temperature, the strip is control cooled to 950 F prior to its immersion into the galvanizing bath. In order to protect the strip surface and provide the best coating adherence qualities, the strip is conveyed through an air-tight "snout" from the furnace into the coating bath below the zinc level.

The coating is immediately applied to the strip in the flux-free zinc bath and bonded to the base metal. The coating thickness is carefully maintained by the height and adjustment of the coating rolls and speed of the strip.

After leaving the coating bath, the strip rapidly cools on the vertical up-pass to produce the spangle pattern that is characteris-

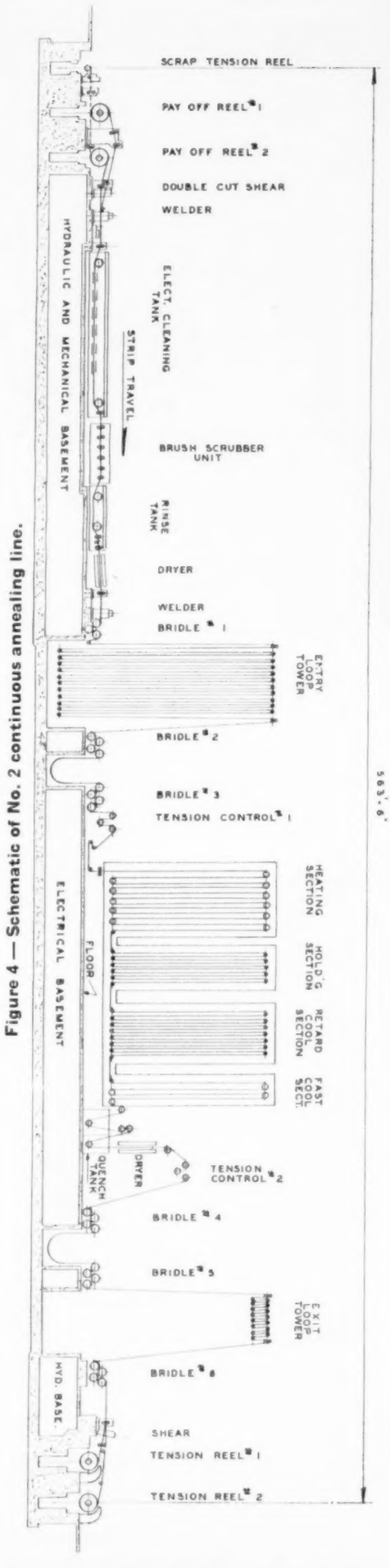
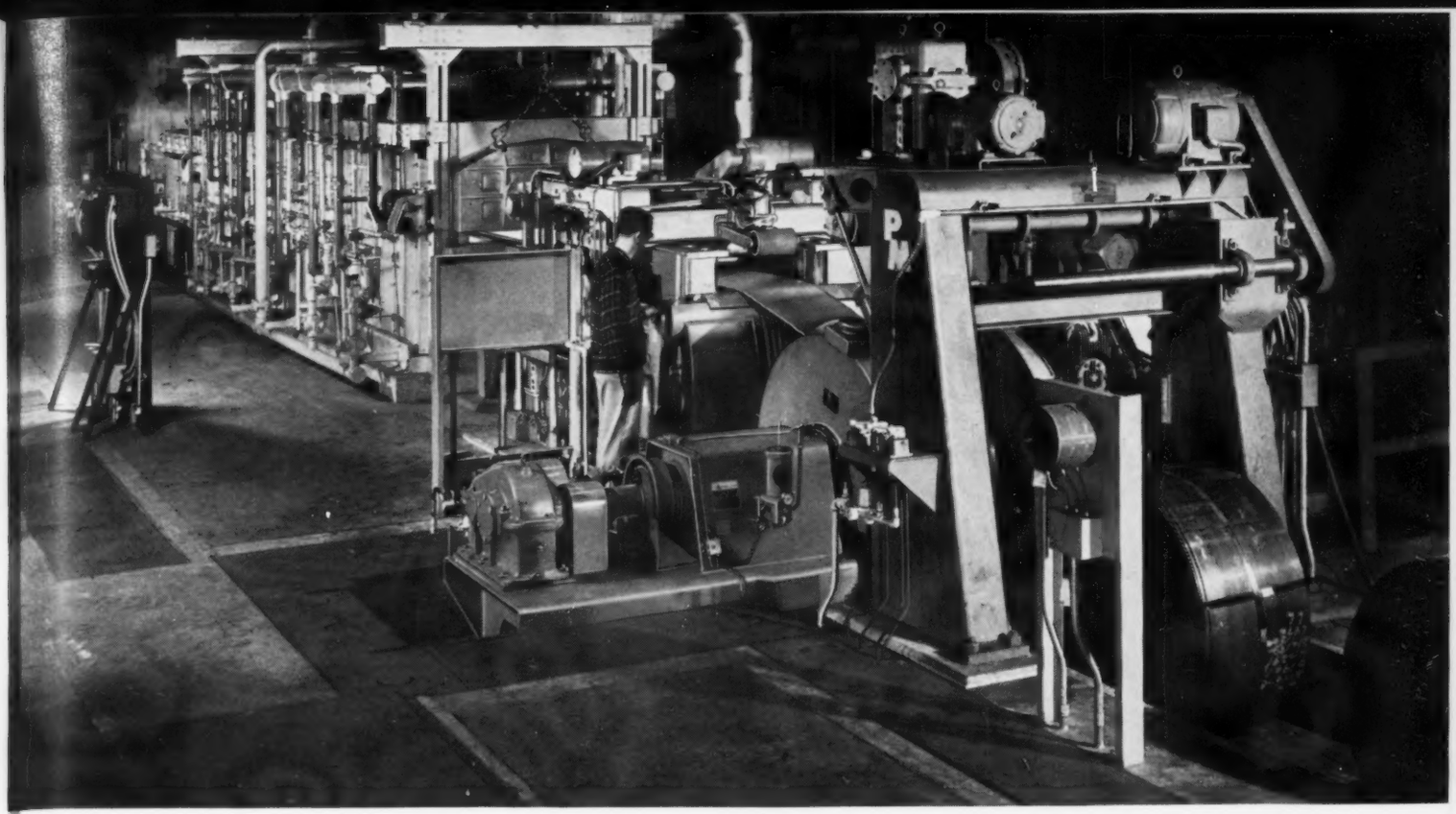


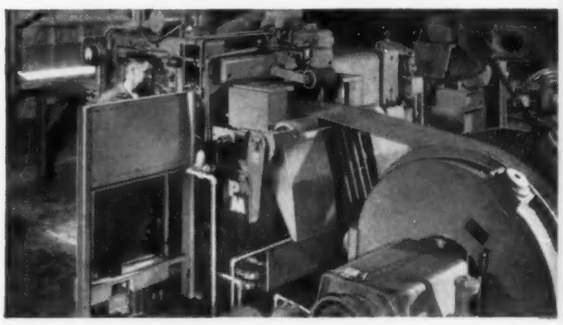
Figure 4 — Schematic of No. 2 continuous annealing line.



at Universal-Cyclops Steel Corporation

P/M self-threading annealing line economically processes heavy gage stainless . . . features rapid, mechanized coil entry

Here's how P/M Equipment eliminates all manual straightening of heavy gage, hot-rolled coil ends: Leading end (0.250" thick) is mechanically peeled from coil (above) and then fed forward to leveler. With entry completed, peeler blade is retracted, and driven holddown roll elevated (below).



At their new Coshocton, Ohio plant, this leading steel producer recently installed the 115-foot tunnel-furnace annealing line shown above. It handles 200 and 300 series stainless coils in gages up to 0.250-inch.

Designed and built to meet Universal-Cyclops' specifications, the line provides — for the first time — a rapid, completely mechanized means of uncoiling, threading and recoiling the material being processed. It's now a simple matter for the line's operator to thread and process a flattened strip with coil-set removed. Production is increased because of minimum delay or downtime between coils being fed through the line. A new coil is entered **immediately** following the tail end of the preceding coil.

It's a most economical setup for Universal-Cyclops because joining and shearing equipment as well as looping or storage pits are eliminated. Production is on a coil-by-coil basis.

This is but another example of how P/M's "Productioneering" helped a leading producer to cut costs — increase both production and product quality. "Productioneering" is our term for the designing and building of the finest metal processing equipment to fit individual customer needs. It will definitely pay you to contact a P/M engineer if you are planning installation of any of the type equipment listed below. Why not call us, today.

Production Machinery Corporation, Mentor, Ohio

Designers and Builders of Metal Processing Equipment including: Lines for pickling, annealing, slitting, shearing and cutting-to-length, grinding, scouring, coil build-up, inspection, as well as other sheet and strip processing machinery.

P M ®

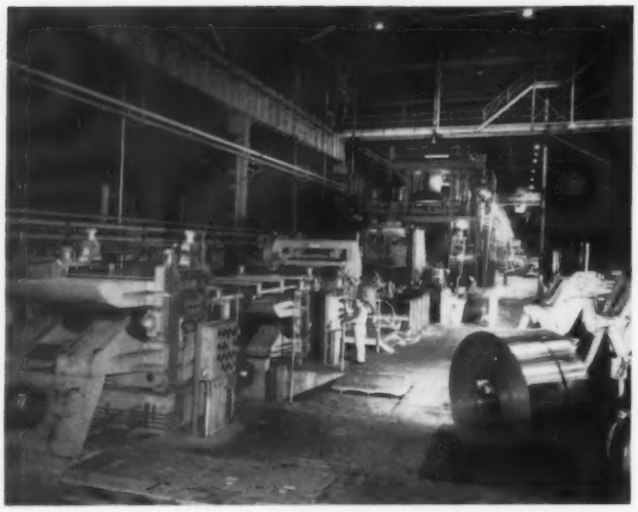


Figure 5 — Coils of cold rolled steel in galvanizing line at the Indiana Harbor plant of The Youngstown Sheet and Tube Co. are coated at a rate of 400 fpm.

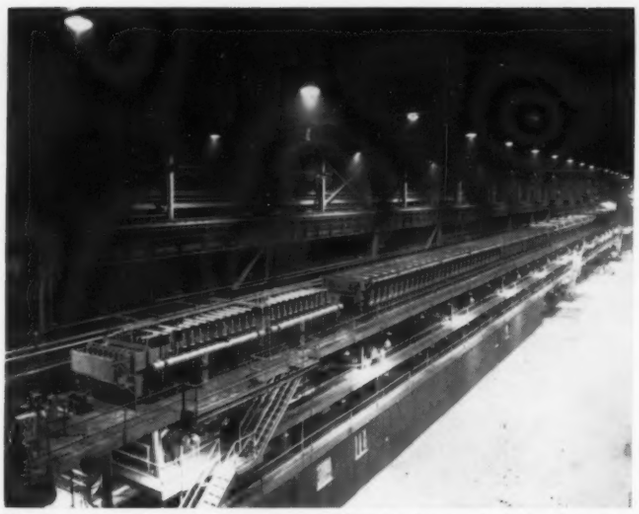


Figure 6 — Furnace section is 528 ft long, believed to be longest presently in use on continuous hot-dip unit.

tic of the sendzimir type galvanizing process.

Cooling air is applied to the strip on the upper horizontal pass to lower the strip temperature. The pull through leveler provides the anti-fluting characteristics necessary for good working qualities of the product.

A series of chemical solution sprays treat the strip surface to prevent the formation of white rust during storage.

The delivery section consists of:

1. Looping car.
2. Two levelers.
3. Printing equipment.
4. Oilers.
5. Shear.
6. Two tension reels.
7. Shear.
8. Leveler.
9. Reject equipment.
10. Piling equipment.

A loop car is provided to store strip during transfer from one tension reel to another and from recoiling to shearing without stopping the processing section.

A total of three Voss levelers is installed to insure flatness to all product. Modern piling equipment is installed to provide a neat and straight pile to prevent edge damage during shipment or prior to use.

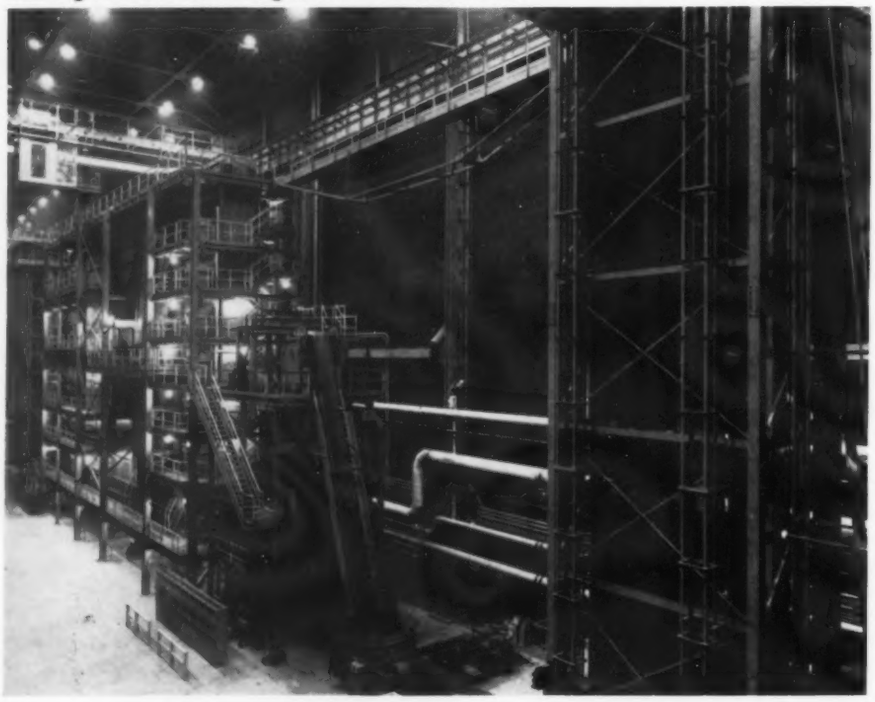
Quality control personnel make continual checks throughout the entire operation to insure all product adheres to the customers' specifications.

A laboratory is located adjacent to the line building to make tests on coating adherence, bending, hardness, elongation, chemical treatment solution and coating bath analysis.

Auxiliary equipment consists of three hydraulic systems and atmosphere generating equipment.

Approximately 15 per cent of the line is located in an existing building with the remaining in a 137 ft-10 in. x 768 ft-0 in. building extension. A 25-ton crane is installed in the building extension.

Figure 7 — Steel is annealed at a speed of 2000 fpm in this new continuous annealing furnace at Youngstown's No. 2 tin mill.



NO. 2 CONTINUOUS ANNEALING LINE

Youngstown's No. 2 continuous annealing line, for annealing strip after cold reduction to tin-plate gage on the 6-stand mill, started production January, 1961.

This is one of the largest and fastest annealing facilities built to date.

The line is designed to operate at a maximum speed of 2000 fpm, with a maximum design capacity of 60 tons per hr, and supplements the No. 1 continuous annealing line which was placed in operation late in 1957.

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ANNOUNCES

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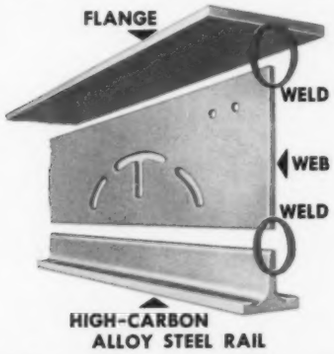
Continuous automatically–controlled welds

Flange, web and rail joined by continuous automatic welds assure reliability.



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another exciting "first"

An outstanding advancement in a long series pioneered by Cleveland Tramrail to make it the leader in the overhead materials handling equipment industry. An entirely new track that had to be great to be better—result of years of research.

a far better track

Balanced design with parts proportioned exactly to provide maximum strength with minimum weight. Greater rigidity to withstand severe working conditions.

easier, faster to erect

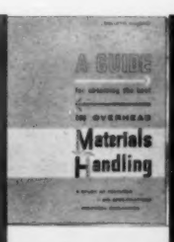
Straight, true, smooth. All dimensions held to greater accuracy. Tarca Track matches with existing Cleveland Tramrail installations.

large range of sizes

10 standard sizes from 8″ to 20″ deep. Special sizes can be fabricated for unusual applications.

Ask for this helpful booklet—No. 2032

Covers all major features the buyer should know about overhead materials handling equipment. Has complete story on Tarca Track. Contains detailed equipment specifications and handy proposal evaluation form.



CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
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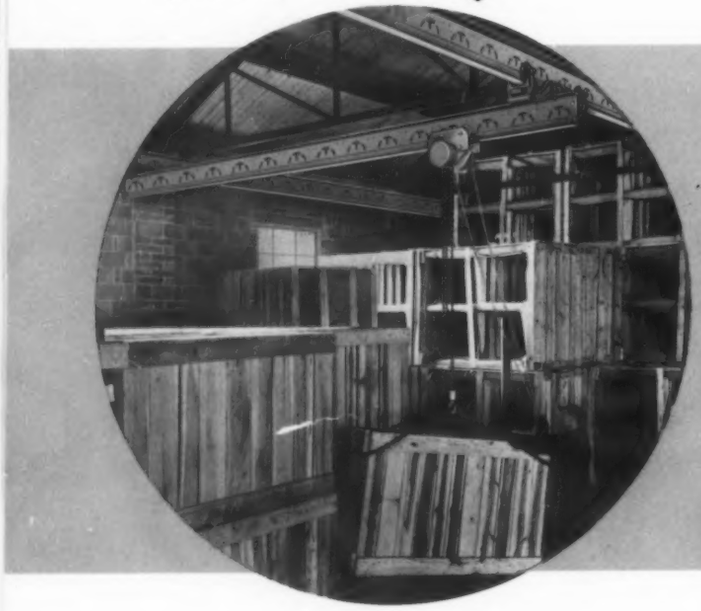
Most Installations of Cleveland Tramrail Equipment pay for themselves within one or two years.

Trade—mark of durability and strength —punched into all Tarca Tracks.

One of the more recent important materials handling developments initiated and engineered by Cleveland Tramrail for the Wire and Rod Industry is the hydraulically-operated grab for storing coils in vertical piles. This device picks up several coils at a time and works in either vertical or horizontal positions.

Simple inexpensive hand-propelled Cleveland Tramrail cranes are filling a mighty important need in a vast number of places. For instance, in this warehouse of a glass distributor, heavy awkward cases are handled by one man and piled high, thereby utilizing the storage space to the maximum.

Cleveland Tramrail gantry cranes have long been popular because they increase efficiency of many local handling situations. They will operate under overhead cranes without interference. Tramrail gantries are built in many types and sizes, with manual or electric drives.



Your Cleveland Tramrail Sales Engineer is Qualified to give you the Complete Design and Application Story on This Revolutionary

NEW TARCA TRACK

Cleveland Tramrail is represented by competent, experienced engineers in all principal cities of the United States and Canada. Contact address on other side.

1—Printed in U.S.A.

The new continuous annealing line is approximately 560 ft long overall, and is made up of the following sections:

Entry section—The entry section consists of two payoff reels and crop shears, strip mash welder, whereby coils are welded together to provide a continuous operation; an electrolytic cleaning section for strip surface preparation, prior to annealing, and a 22-strand, 70-ft high storage looping tower capable of storing 1600 ft of strip. This looping facility provides sufficient strip to provide continuous operation through the furnace section, while the entry section is stopped for end welding of coils.

Furnace section—The section consists of a tower type continuous annealing furnace, which is approximately 70 ft high from floor line to top of structure and approximately 135 ft long. The furnace is made up of four sections: heating, holding, retard cooling and fast cooling section. In the heating section, the strip is heated by natural gas-fired radiant tubes to an annealing temperature of 1250 to 1350 F, while under a protective atmosphere of a mixture of approximately 93 per cent nitrogen and 7 per cent hydrogen. The strip while still in the protective atmosphere, enters the holding section, whereby the strip is held at a uniform annealing temperature for approximately 25 sec; from the holding section, the strip passes into the retard cooling section, and in this section, while still under a protective atmosphere, the strip temperature is reduced from the 1250–1350 F annealing temperature, to approximately 750 F at a controlled rate of cooling. The final furnace section, the fast cool section, receives the strip at approximately 750 F, and employs a jet cooling principle in reducing strip temperature to approximately 450 F, prior to strip leaving the furnace proper.

Immediately after leaving the furnace, and while still under a protective atmosphere, the strip is quenched in water to a temperature of approximately 180 F and dried by hot air blast.

Immediately ahead of the furnace, and also after the above hot air blast dryers, electronically-controlled tension regulating drives are employed to regulate strip tension through the furnace.

Due to the size of this furnace, a closed circuit TV system with four cameras is used to continuously monitor the strip during its travel through the furnace.

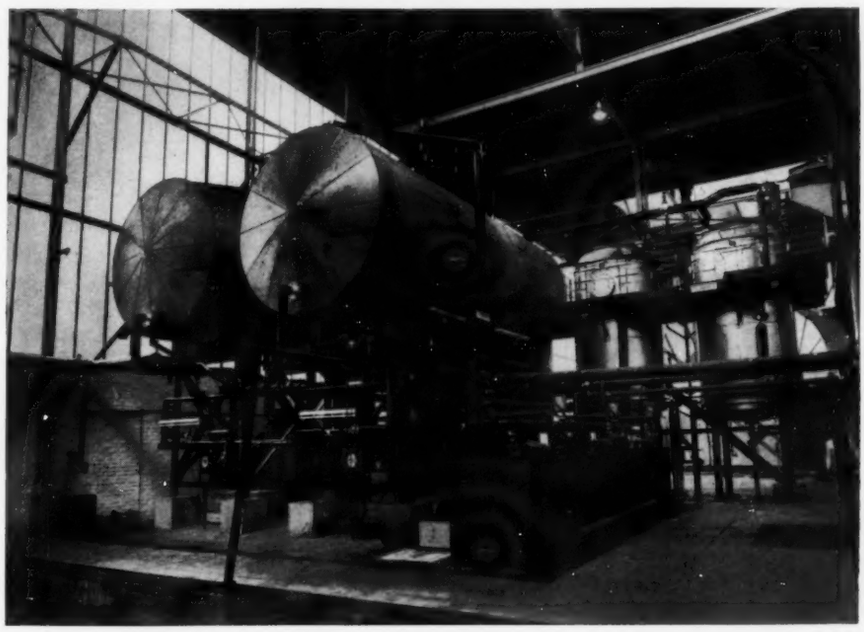
Exit section—The exit section of the line includes a secondary looping tower of 16 stands for storing 1150 ft of strip so that the strip may be wound on either of two tension reels, without stopping strip while coils are being removed from the tension reels.

The line has approximately 6000 ft of strip in transit during operation and approximately 2300 ft of this strip is in the furnace section.

The line is enclosed in a new building 480 ft long x 90 ft wide, and serviced by a 7½-ton crane.

Auxiliary equipment includes two hydraulic systems and additional facilities for generating the protective atmosphere gas. ▲

For Complete Rolling Mill Oil Recovery and Water Clarification Consult TITZEL



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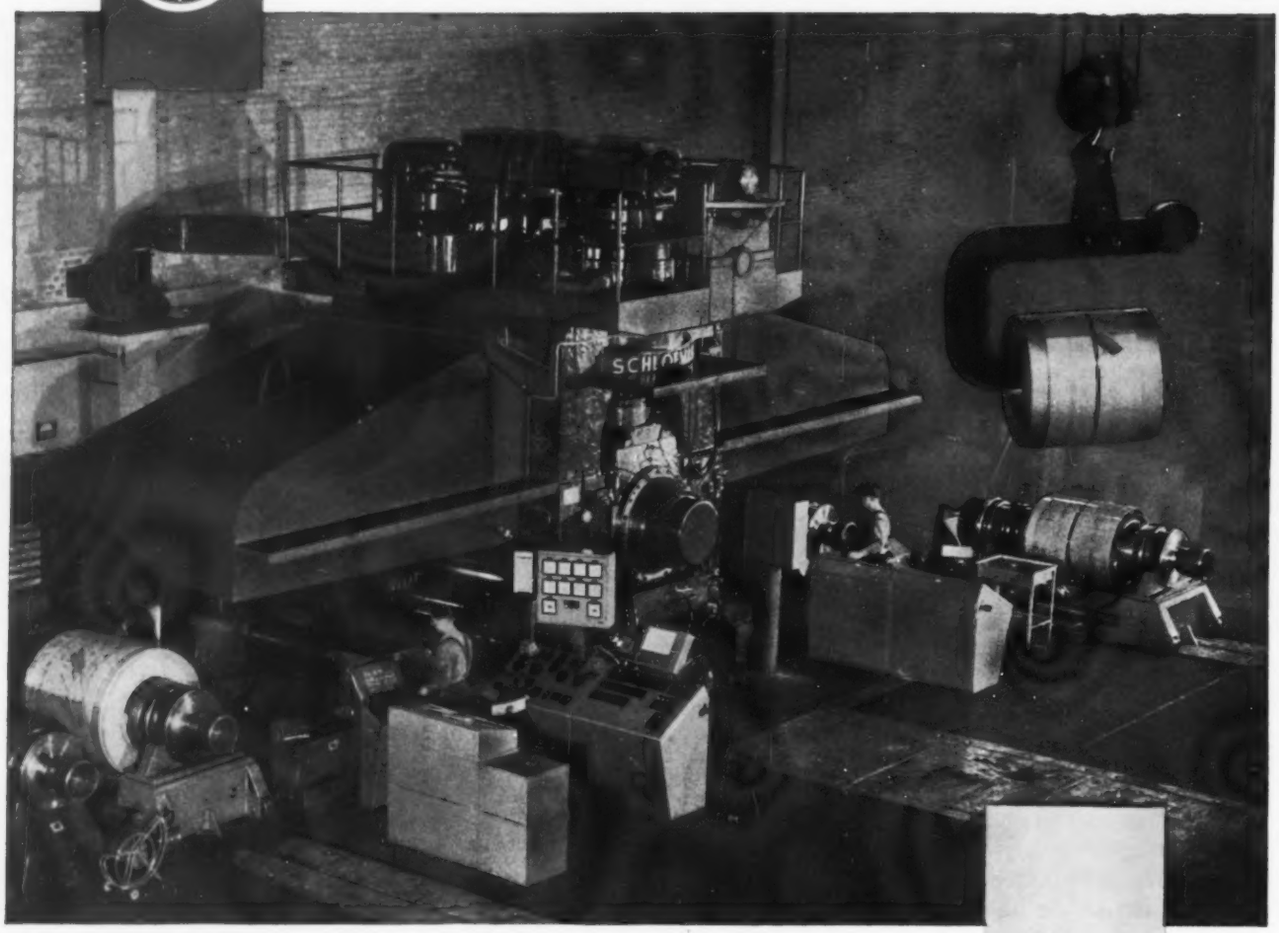
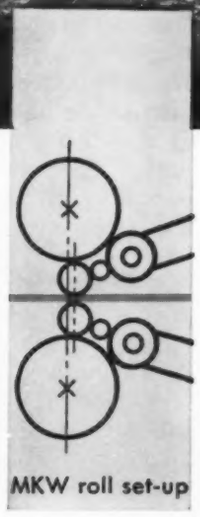


MKW mill rolling alloy steel strip 50 in. wide in a Swedish steel plant



MKW roll set-up

MKW in Sweden

For the past three years an MKW mill in Sweden has rolled wide alloy steel strip. MKW rolling mills in Europe, North and South America today produce many thousands of tons of high-grade steel and non-ferrous strip every year. MKW mill stand designs are patent-protected. Constructed on simple lines they are thoroughly dependable. As small-diameter work rolls are used at high speed, large pass reductions and close tolerances are obtained.

MKW rolling mills can be equipped with four types of roll set-up (two-high, four-high, MKW and double MKW), and as a result their range of application is correspondingly expanded.

FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

HOT AND COLD ROLLING MILLS • COUNTERBLOW HAMMERS • HYDRAULIC PRESSES

Bethlehem Sucessfully Ends Experimental H-Iron Program

THE successful completion of Bethlehem Steel Co.'s experimental H-Iron program was announced. The necessary data have been obtained and no further operations are scheduled for the present at its pilot H-Iron plant at Los Angeles.

Further exploitation of this process depends on need for primary iron production facilities, for which Bethlehem has no immediate plans for its West Coast operations.

Bethlehem's interest in the process, jointly developed with Hydrocarbon Research, Inc., who are also the exclusive licensors, dates back more than ten years when the steel company began searching for a method of producing iron in areas where metallurgical coke and limestone, necessary blast furnace ingredients, are not readily available.

Together with Hydrocarbon, Bethlehem scientific and engineering personnel worked out a method whereby iron ore would be reduced by hydrogen gas to produce iron, and the method was proved in a small pilot plant in Hydrocarbon's laboratories.

Bethlehem then decided to build a pilot H-Iron plant sufficiently large to permit a convincing demonstration both of the process and the characteristics of the product when charged into steelmaking furnaces.

A pilot plant designed to produce at the rate of 110 tons per day was erected at the company's southern California facilities. This location was chosen because of potential interest in application of the process on the West Coast where the company now has no blast furnaces.

The pilot H-Iron plant resembles an oil refinery in appearance and consists of three major units, an oxygen plant, a hydrogen plant and an iron reduction plant. Oxygen is combined with natural gas to produce hydrogen, which in turn acts upon the iron ore in the reduction plant to form metallic iron.

Figure 1 — The briquettes are passivated in a furnace at 1600 F to prevent reoxidation.

During actual production, pulverized iron ore was fed into the top of a cylindrical steel vessel which, with all its equipment, weighed 238 tons and measured 122 ft-6 in. high. Hydrogen, meanwhile, was introduced under pressure into the bottom of the vessel.

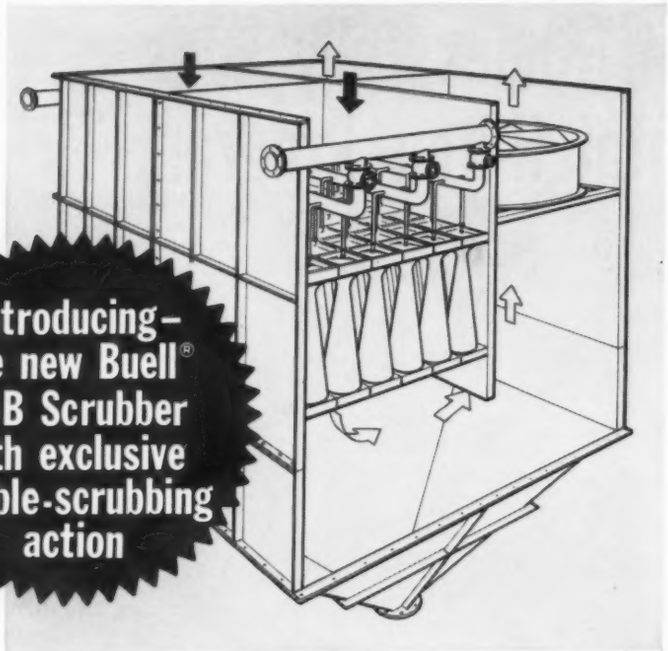
The hydrogen and iron ore met in a series of four fluid beds at a temperature of about 850 F and a pressure of about 440 psi. Upon discharge from the vessel the iron powder was briquetted and passivated in a special furnace at a temperature of 1600 F to prevent it from reoxidizing.

During the test runs, the oxygen and hydrogen plants operated as scheduled and with high availability. A number of changes were made in the reducer and toward the end of the program it also operated with high availability.

Although the rated capacity of the pilot plant was 110 tons per day, in the final phases of the program it actually produced 121 tons per day of 95 per cent plus reduced powder. Of particular significance is the ability of the process to produce highly reduced iron powder at a low operating temperature.

Full-scale melting tests of briquettes in electric furnaces showed that a consistent degree of reduction resulted in a consistent practice. With 95 per cent reduced H-Iron briquettes up to 30 per cent of the charge, indicated differences in heat time, power consumption and fluxes, as compared with scrap charges, were small. Above 30 per cent of the charge, the gangue in the ore used, caused some increase in these factors. Yields for 95 per cent reduced H-Iron heats were the same as for non H-Iron heats. Lower degrees of reduction increased heat time and power consumption and decreased yield.

Of interest were the results of production heats made in the final phases of the program in which pyrophoric H-Iron powder, not briquetted or passivated, was charged directly into an electric arc furnace. Up to 40 tons of 95 per cent plus reduced powder, 40 per cent of the charge, was melted smoothly with normal yield and slight increases in heat time, power consumption and fluxes. An important advantage of H-Iron over scrap was its freedom from contamination by other metals. ▲



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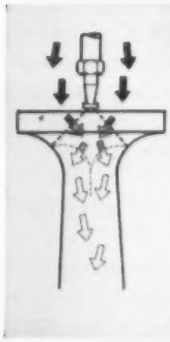
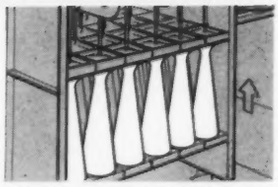
Service-proved in applications around the world, the new Buell W-B Scrubber is now available for sub-micron dust removal jobs in this country. This newest multi-venturi wet collector removes over 99% of dust as small as 0.05 microns. Licensed under the famous Waagner-Biro patents, the new Buell W-B Scrubber offers several distinct benefits over other wet collectors. The most important are discussed below. ■ There are other operating advantages, too, including low water requirements, and case-hardened venturi throat to resist erosion. But why not check into the Buell W-B Scrubber for your own application? For details, write Buell Engineering Co., Inc., Dept. 60-I, 123 William St., New York 38, N. Y.
■ cyclones · electric precipitators · bag collectors · combination systems · classifiers · venturi scrubbers.



double-scrubbing action Exclusive! Water is introduced ahead of the venturi, which forms two distinct cones for gas to pass through

typical iron and steel industry uses oxygen converter dust—open hearth dust—ferromanganese fumes and ferrosilicon dust from electric furnaces—iron, coke and silica dust from gray iron cupolas—iron, carbon dust from rotary kilns—Taconite ore dust from crushing and screening.

low power This special design achieves the desired efficiencies with low pressure drops; thus, requires minimum power
■ **high efficiency** The Buell W-B Scrubber offers efficiencies for given conditions higher than any similar system.



any capacity The new Buell W-B Scrubber is made up of multiple venturi tubes—each a standard, readily-stocked item. Capacity for your application is arranged simply by designing for the proper number of venturi tubes.

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Special Planing Equipment Squares Plate for Welded Pipe

HIGH-strength steel plate for large diameter expanded welded pipe is planed accurately at record production rates in the Steelton plant of Bethlehem Steel Co.

Special plate planing equipment, instrumental in the mill's production of expanded pipe for high-pressure natural gas, trims planing time almost in half. At the same time, it provides the square cuts necessary for top quality welded joints.

The heavy-duty planer was built by Birdsboro Corp. to handle up to 25,000 tons of plate per month, enough plate to produce approximately three miles of 18 to 42-in. OD pipe per day.

Individual plates, ranging up to $\frac{3}{4}$ in. thick, weigh from 1 to $7\frac{1}{2}$ tons each. All plates are 40 ft-6 in. long prior to planing, and widths vary from 52 to 130 in., depending on the pipe diameter. At peak production, the equipment planes both sides and both ends of one plate every two to three min.

Material for forming the pipe is delivered by rail cars and unloaded by a 20-ton magnet crane. Plates are stacked on either side of a roller-type receiving table just outside the mill. A fully automatic, one-legged gantry crane of 15-ton capacity then takes over the feeding. The gantry, designed by Birdsboro for either automatic or manual operation, is equipped with suction cups which vacuum lift one plate at a time and place it on the receiving table. Powered rolls move the plate from receiving table to feeding table.

When the last plate of the stack actuates a limit switch, the gantry automatically stops in the home position. It is then switched over to pick steel from the second stack of plates on the opposite side of the receiving table. Meanwhile, the magnet crane in the yard can replenish the first stack.

Chain-driven rollers convey the plate, through a slit in the side of the building, to the double-side planer. Before the plate enters the planer, it is positioned by two hydraulic squaring jacks against the stationary side to assure a square cut.

Two cutting carriages, one on either side of the planer, strip off up to $\frac{1}{2}$ in. from each side of the plate. Both sides are planed simultaneously in about two min. Operators in the two carriages, using grippers, pull the plate on rolls into the machine and release it for cutting. The plate is positioned on two clamping supports and centered for the cutting pass. A 41-ft

Figure 1 — Both sides of the plate are planed in a single pass.

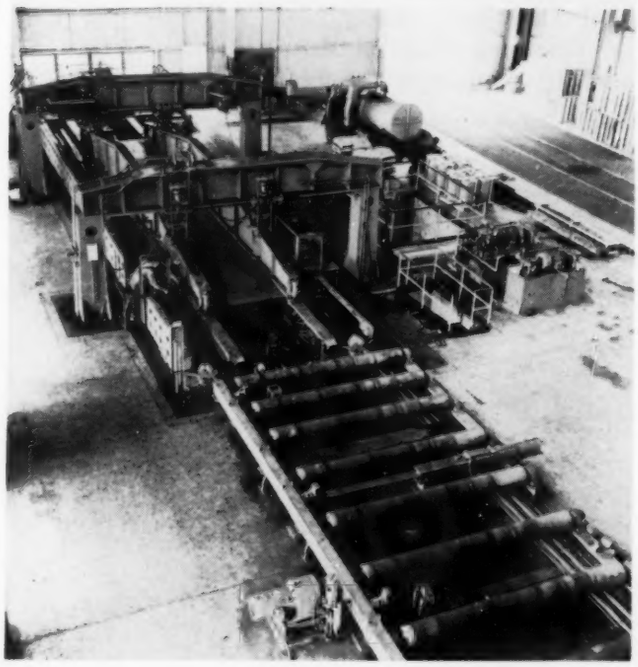
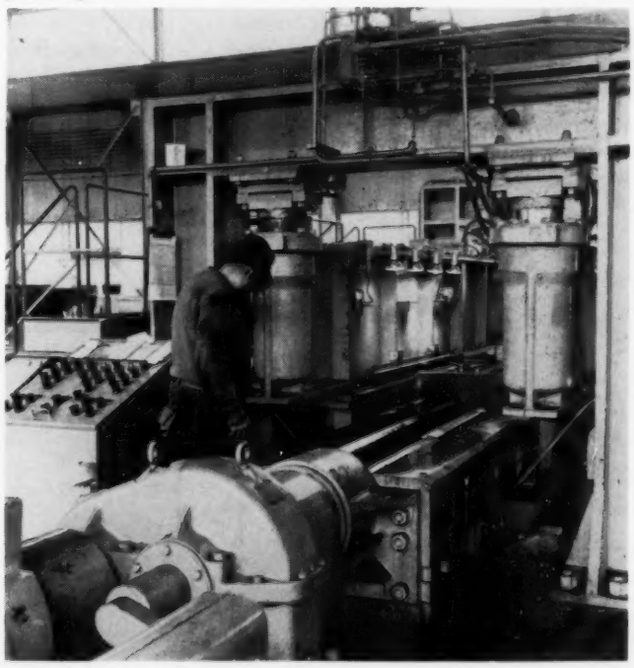


Figure 2 — Photoelectric cells spot the front edge of the plate at the proper position to ensure a square edge after planing.



hydraulically-operated beam clamp descends to hold the plate down along its full length.

The machine is unusual in that it planes in only one direction, taking a single cut. On the down stroke it brings a new plate into position and automatically ejects a finished plate. It cuts on the back stroke, at the end of which it is ready to repeat the cycle. Thus there is no lost motion. Planing time, in fact, is approximately half that required using conventional planing equipment.

Each traveling carriage is equipped with 12 cutting tools designed and mounted to take a progressive cut. The planer, driven by a 300-hp variable-voltage d-c motor, cuts heavy plate at an average rate of 60 fpm. It is designed for travel at 34 to 102 fpm.

The entire planer moves laterally for width adjustment. One side is stationary for lining up the plate, while the beam clamp and carriage on the opposite side move with the work table to accommodate plate of varying width. Sag is prevented in extra wide plate by a special centering device. This device always stays in the theoretical center of the plate because it is indexed to move exactly half the distance of the outside clamping head when width adjustments are made.

A special chip disposal system eliminates the need for sweeping and also avoids danger of damage to the screw box or other parts of the machine from loose chips. It is designed so that chips from the planing operation drop onto a vibrating conveyor which leads to a central chip box.

After the sides of the plate are cut, the stock is ejected and rolled onto the end planer approach table. As it enters the end planer, the plate is squared against the stationary edge by hydraulic jacks. Four photoelectric cells automatically stop the plate in the proper position for cutting to size. The plate is first clamped and cut on the leading end. Then it is moved, stopped again by an electric eye, clamped and cut on the trailing end.

Unlike a shear, the planer can put a bevel or any shape desired on the ends. Hydraulic squaring devices, used in planing both the leading and trailing ends, help assure a square cut and a truly rectangular plate.

One combination carriage, equipped with eight tools on each cutting side, removes up to $\frac{5}{16}$ in. of stock from each end of the plate. The end planer, driven by a 75-hp variable-voltage d-c motor, travels laterally at a rate of 46 to 107 fpm. Manned by an operator, the carriage planes the leading end with one set of tools and the trailing end with the other. After end planing, the plate moves on for further processing. ▲

Precoating Line Installed by Pre-Finish Metals, Inc.

THE precoating of metals is the application of a final finish to a metal which has not yet been fabricated.

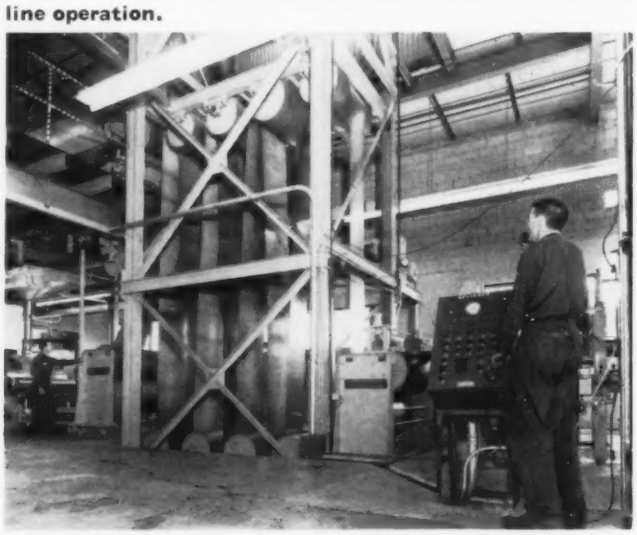
Pre-Finish Metals, Inc. is now operating its new metal coating line at near peak capacity. The line, 450-ft long, is housed in a new wing of the building, which was erected specifically for this purpose. The line can double-coat coil stock up to 48-in. wide. A 7-stage cleaning and processing operation assures positive coating adhesion and continuity in the coatings. Peak capacity of the unit has not been achieved, but it is estimated that the initial output of 350 tons daily can be easily exceeded, a company spokesman said.

Pre-Finish Metals, Elk Grove Village, Ill., is one of the pioneers and developers of the precoating of metal coils and sheets. Its precoated, preprinted and laminated sheets and metal coils are molded, die-cut, deep drawn, stamped and punched into metal products that require no further finishing.

The facilities of the new plant provide for the single or double coating of metal coils up to 48-in. wide in gages of 0.004 to 0.062 in. It can handle steel sheets in widths of 18 to 60 in., lengths of 4 to 12 ft and gages from 0.012 to plate. ▲

Figure 1 — The strip may be coated on one or both sides as desired, in a variety of finishes.

Figure 2 — The tower accumulator permits continuous line operation.



EDERER
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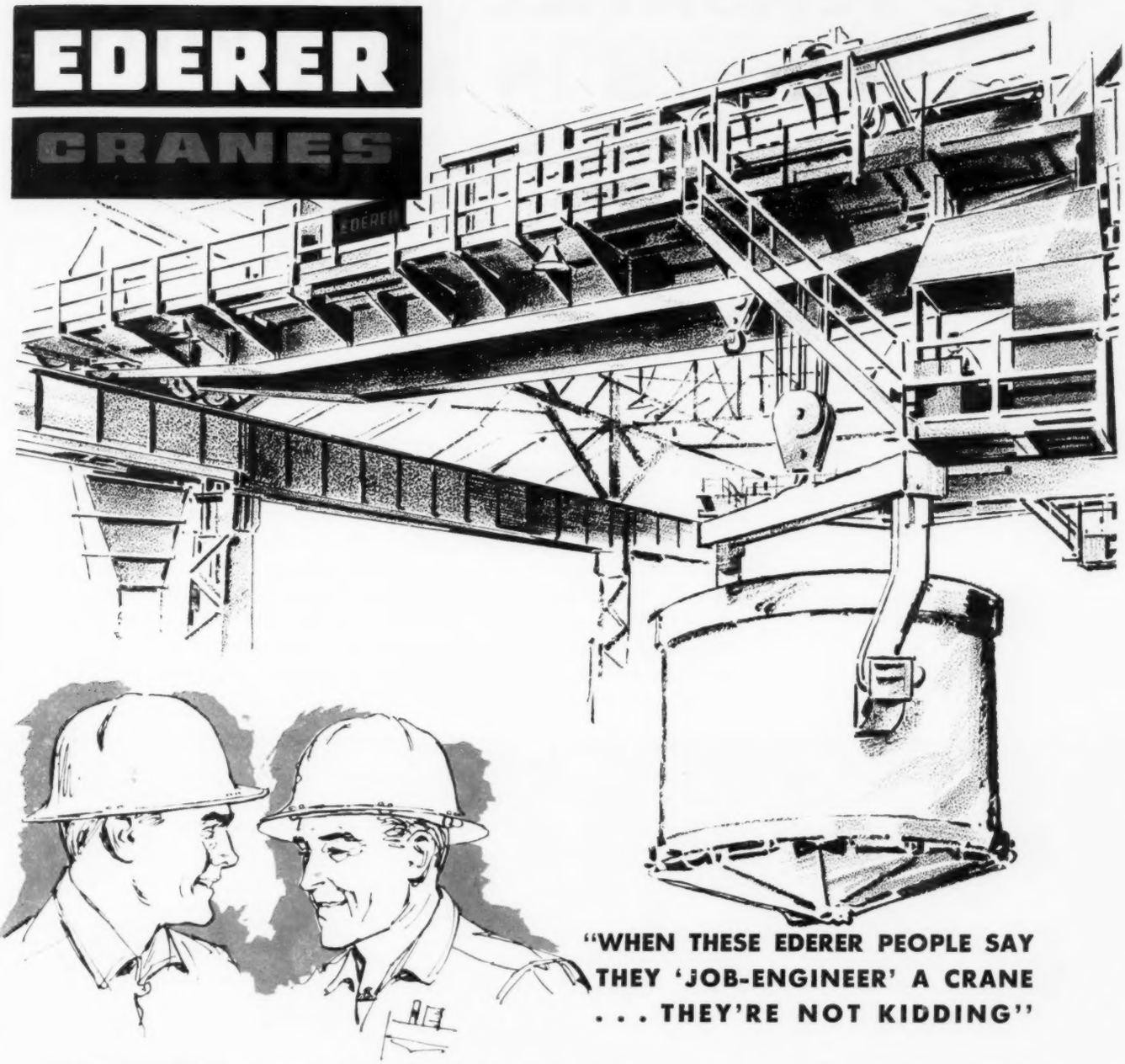

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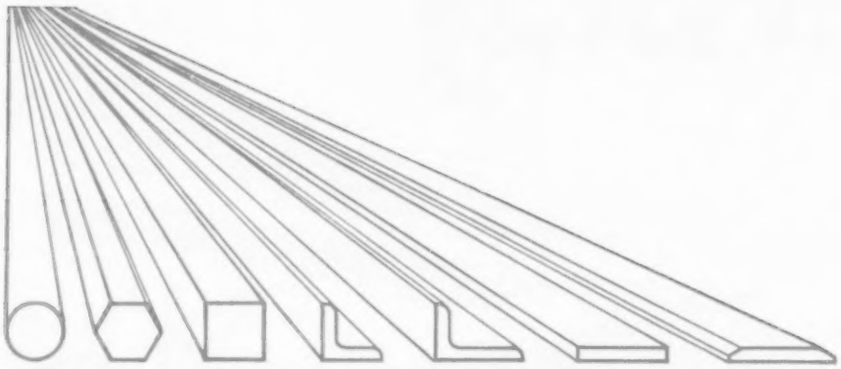

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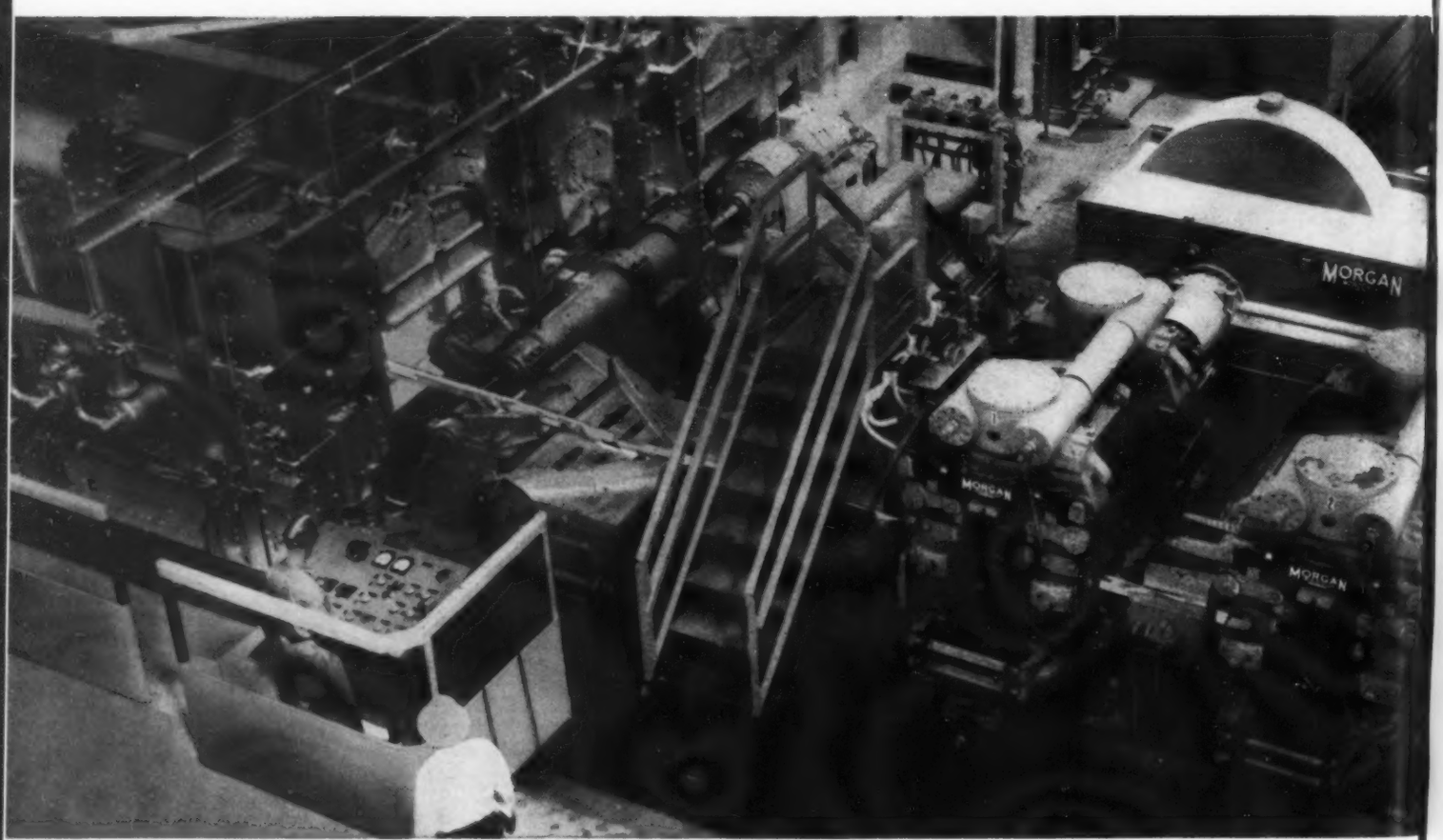

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Recent Improvements in Roll Etching

by C. P. CROFT, Project Engineer, Pangborn Corp., Hagerstown, Md.

UNIFORM quality of finish on rolled steel has become so important to the automotive industry that the Society of Automotive Engineers (SAE) has formed a committee to seek out a set of standards. This group is called the Iron and Steel Technical Committee on the Problem of Surface Texture. Moreover, the previously accepted method of measuring surface roughness with a profilometer is considered inadequate. Republic Steel Corp.'s Electromechanical Research Center has developed an instrument, known as the "Surfacount," to count the number of peaks and valleys per lineal in. imparted to the plate by etched rolls. Some feel that even this measurement is not the final answer to quality control.

The first blast etching of a mill roll was done on an experimental basis, to slightly roughen steel coil surfaces to prevent sticking during annealing. The equipment for this purpose was developed by Pangborn Corp. for a Chicago mill in 1934. The project was regarded as highly secret and a fence was built around it to keep anyone (including Pangborn personnel) from finding out the exact use and the results of the new process.

The roughened surface accomplished more than had been hoped for. It led to improved painting, enameling and plating of finished products. It provided a surface more easily held in forming dies.

It was customer acceptance of the new sheet surface which forced the steel mills into use of automatic blast equipment to provide rapid, uniform coverage of their mill rolls.

In the early stages of this process production requirements were low and varieties of finish required were few; therefore, the relatively slow method of blasting rolls by using compressed air to propel the abrasive was acceptable.

However, with increasing demand for the new product, blast etching equipment with greater capacity became essential, which led to the use of grit-blast wheels with controlled and co-ordinated speeds and abrasive flow. These wheels, spinning at high speed, accepted the shot and propelled it in a preset direction using centrifugal force as the propellant. Then the need for a wider range of finish grew. More rigid control of abrasive classification was demanded. Abrasive classification had become the bottleneck.

Initial centrifugal blast installations used a rectangular vibratory type screen, approximately 3 ft-0 in. wide by 8 ft-0 in. long. Designers soon determined that three screen decks were the most that could be used with existing vibrating equipment.

A screening capacity of 400 lb of cast-iron grit per min, at an average weight of 250 lb per cu ft was established as a requirement. This was set as a round figure, based on a possible blast wheel speed of 2350 rpm using a 20-hp motor, with the classifier having the capacity to screen the full flow of abrasive from the wheel.

Screen materials became a problem. Standard wire screens would blind, thus reducing screen capacity. The size of the screens made them difficult to remove for cleaning. Screen life was also a problem. Silk screen cloth was tried instead of wire. This minimized the blinding condition, but the silk did not wear well. Nylon cloth finally solved the wear problem while blinding conditions remained improved as with silk.

However, nylon presented a new problem, for friction between the metal abrasive and the screen cloth generated a static condition which retarded the flow through the screen orifices and thus reduced the screening capacity. To overcome this, screens with oversize openings were used, but this did not permit screening to a close tolerance.

A 48-in. diameter circular classifier was obtained and set up for testing. The circular separator offered several advantages: less space was required; blinded screens were easily cleaned; and worn screens were easily changed.

The presence of fines in the screened coarse grit then presented another problem. Without control over the volume of fine, one cannot maintain a constant mixture. Consequently a different roll finish would result from one roll to another even though grit from the same bin was used.

Providing an abrasive bank and metering the flow to the classifier solved the problem. It was then possible to classify approximately 200 lb per min and screen the excess during the period when a roll was removed from the work car and a new one put in place.

With adequate storage above the blast wheel and a bank ahead of the classifier, it is possible to satisfactorily blast etch one roll of any practical mill size every 15 min. Maximum roll size handled to date is 32-in. diameter with a 90-in. long face.

Even with reduced flow to the classifier, it has been found necessary to by-pass the flow from any screen of coarser mesh ahead of the selected screen. Continued blasting with a fine grit will result in some carry-over on the coarser screens, with a resulting strata of fine in a coarse bin.

When centrifugal blasting was first employed in roll etching, the abrasive-throwing unit was movable and the blast stream was traversed along the face of the roll being etched. A work car was provided to transport the roll into and out of

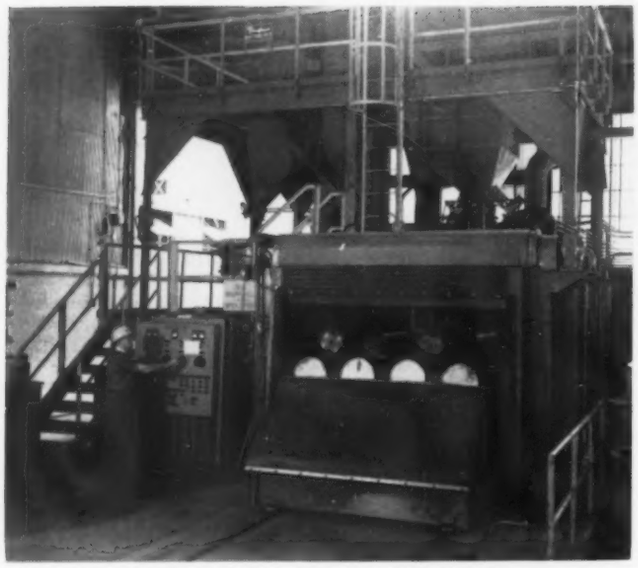

Figure 1 — The grit size, car speed, roll rotation speed and wheel blast speed are set prior to the start of the operation.

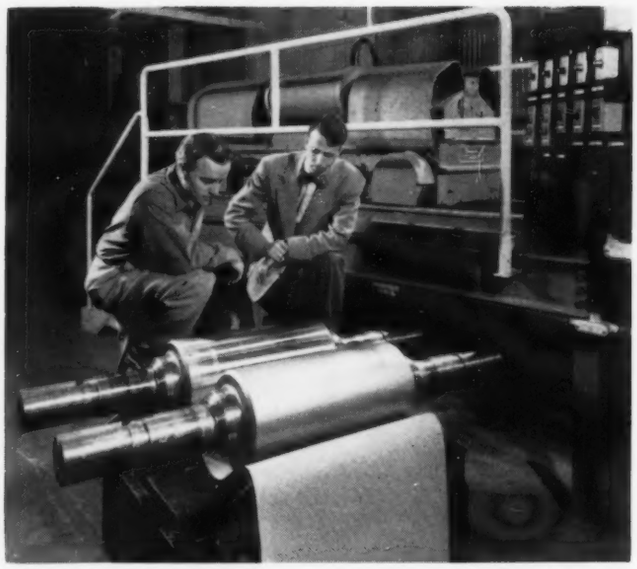

Figure 2 — The etched roll has a marked contrast with a normally finished roll.

the blast room. Once in blast etching position, the car remained stationary while roll adapters supported and rotated the rolls.

In later designs, rubber-covered parallel rolls were provided on the work car and the mill roll is nested between them, eliminating the use of adapters. The roll rotating drive is mounted in the work car. When this design change was made, the traverse mechanism was put inside the car also and the car holding the roll was driven under a fixed blast wheel.

Rubber boots are provided to mask the mill roll necks. At this date, with cars operating three 8-hr shifts a day, seven days a week for a period of five to six years, there has been no known replacement of rubber-covered work rolls.

With classification limiting the number of grit sizes to four, to obtain a wider variety of finishes a variable car speed was necessary. Speeds best for effective blasting were too slow for transporting the car to and from the blast room.

A car drive employing a motor-generator set, converting alternating current to direct current and permitting an over-all speed variation of 16 to 1, was selected. This drive provides a variable slow speed ratio of six to one with a fixed high speed. Most installations now use a low speed of one to six fpm during blast etching and a high speed of 16 fpm for movement outside the blast room. Roll rotation is also variable with either a-c or d-c varispeed drive. New types of variable-speed drives are now being investigated.

Power to the car is supplied through two cable reels. Car drive has shear pin protection and car wheels are special hardened steel for long life. There are greatly improved seals on drive compartment covers and covers have been made easily removable for access.

To provide still wider finish ranges, a variable-speed drive is furnished for the blast wheel. Average wheel speeds are from 1150 to 2300 rpm. A tachometer indicates wheel speed.

With four grit sizes, variable car speed, variable roll rotation and variable wheel speed, roll finishes in the profilometer range of 15 to 700 rms are obtainable on rolls averaging 70 to 95 Shore scleroscope hardness. Highest readings are obtained on rolls of least hardness, using coarse grits. Some mills have gone to the extent of reducing roll hardness to obtain desired finish.

Rolled steel finish using rolls etched with this process vary depending on roll pressure and steel hardness. A coarse finish as high as 500 rms has been obtained.

For example, one mill using grain iron rolls, double poured, with a Shore hardness of 76 to 80 uses G-16 grit and a wheel speed of 2300 rpm to obtain a reading of 500 to 700 rms on the roll and 400 to 600 rms on the rolled steel. This requires two complete blast cycles at car speed of one fpm.

On forged steel rolls, 60 to 64 Rockwell C, this same mill uses G-25 abrasive, a wheel speed of 1500 rpm and one car cycle at one fpm to obtain a finish of 175 to 185 rms on the rolled steel.

With the same set of conditions, by increasing wheel speed to 1800 rpm they increase roll finish to a maximum of 225 rms, 115 rms on plate. Wheel is powered by a 20-hp motor.

The blast room is provided with mild steel wear plate protection on side walls and ceiling in the area required and all wear plate joints are overlapped. The main door of the room is a rubber-covered steel mesh roll-up door so constructed that if a limit switch should fail to stop the work car in its outward traverse, the door would push out of its guides with little or no damage.

Latest design installations incorporate standard abrasive handling components. These include either gravity hopper, screw conveyor or vibrating type conveyors to convey abrasive to an elevator with shaft-mounted reducer drive, through an air wash separator to the storage bank above the classifier.

In roll etching, finer sizes of grit are constantly manufactured and the storage bins under the classifier are provided with overflow spouts to feed the accumulation of grit to auxiliary bins at floor level. Grit from the selected storage bin is fed to the blast wheel while grit from the auxiliary bins can be used to

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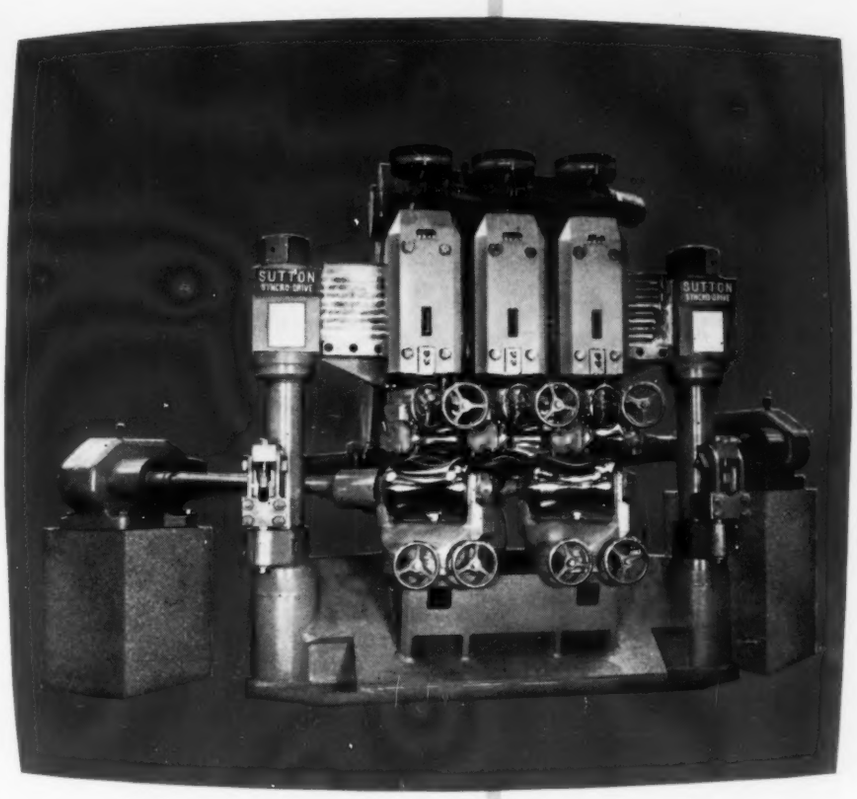

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replenish the storage bins if required.

Low-level bin indicators are supplied to warn when grit should be added.

To prevent overloading the blast-wheel drive motor, it is necessary to reduce the flow of abrasive to the wheel when operating at reduced rpm. Volume can be controlled by changing an orifice plate in the abrasive gate or can be remotely controlled by a variable orifice gate. Sometimes, to obtain a certain finish, volume is also reduced at higher speeds.

For many years chilled-iron grit was the best abrasive for mill roll etching, but improvements in abrasives have kept pace with improvements in equipment. A steel grit of special hardness is widely used with far better results. Four factors are responsible: hardness, size, sharpness and durability.

Hardness—Recent comparison tests of chilled-iron roll etching grit and the A hardness steel grit showed that the steel product averaging 4.9 Rockwell C harder than the chilled-iron grit. Perhaps more important, the chilled iron ranged over a spread of 11.5 compared to only 3.9 for the steel. The consistently higher and more uniform hardness of the steel product is considered an important advantage in roll etching operations.

Sizing—Some mills require specially screened sizes for very critical finishes and these are available in the new steel grit.

Sharpness—Depth of penetration being of particular importance in roll etching, sharpness is an important consideration and again users report the steel grit excels.

Durability—Steel grit, being tougher than the chilled iron, retains both its accurate size and its sharpness longer in use. These factors added to the higher hardness should logically provide a deeper, more uniform etch. ▲

Computer Programmed Stockhouse Starts Operation

THE world's first automatically controlled blast furnace stockhouse has gone into operation at United States Steel Corp.'s Gary plant.

The computer controlled system, designed by Meissner Engineers in cooperation with U. S. Steel engineers and production specialists, automatically withdraws the various materials used in the production of pig iron from a series of storage bins, assembles them in precisely accurate proportions, then charges and feeds the 26.5-ft diameter No. 8 blast furnace at the mill, all according to a preset charging plan.

As a result, fluctuations in the smelting process are reduced. Yet, proportions of materials can be instantaneously changed, simply by changing selector switches on the programming system.

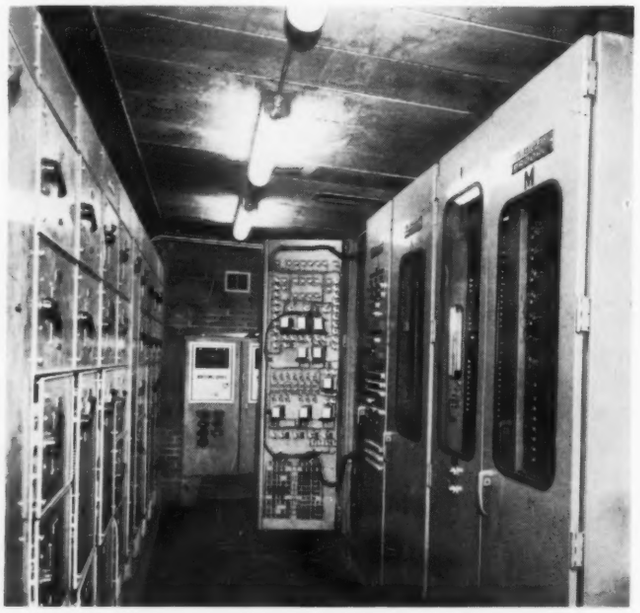
Almost instantly after charging, the system provides a complete and accurate read-out of weights and an accumulation of data on all charging operations.

The new system can be adopted to either a new or existing stockhouse, and it is predicted that it will change the now familiar look of stockhouses in steel mills throughout the U. S.

Although automatic controls in various stockhouse functions have been known in the past, the computer controlled stockhouse at the Gary mill is the first such facility to have a fully integrated control system. ▲

Figure 1 — Each bin is equipped with a weight-determining scale feeder which drops the material onto the collecting conveyor beneath.

Figure 2 — Programmed charging cycles can be quickly changed by means of selector switches located in the stockhouse control room.



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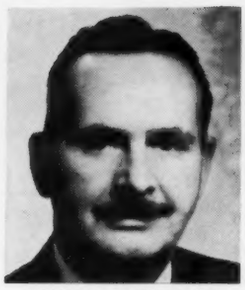

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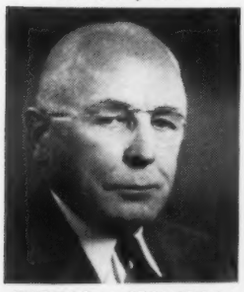

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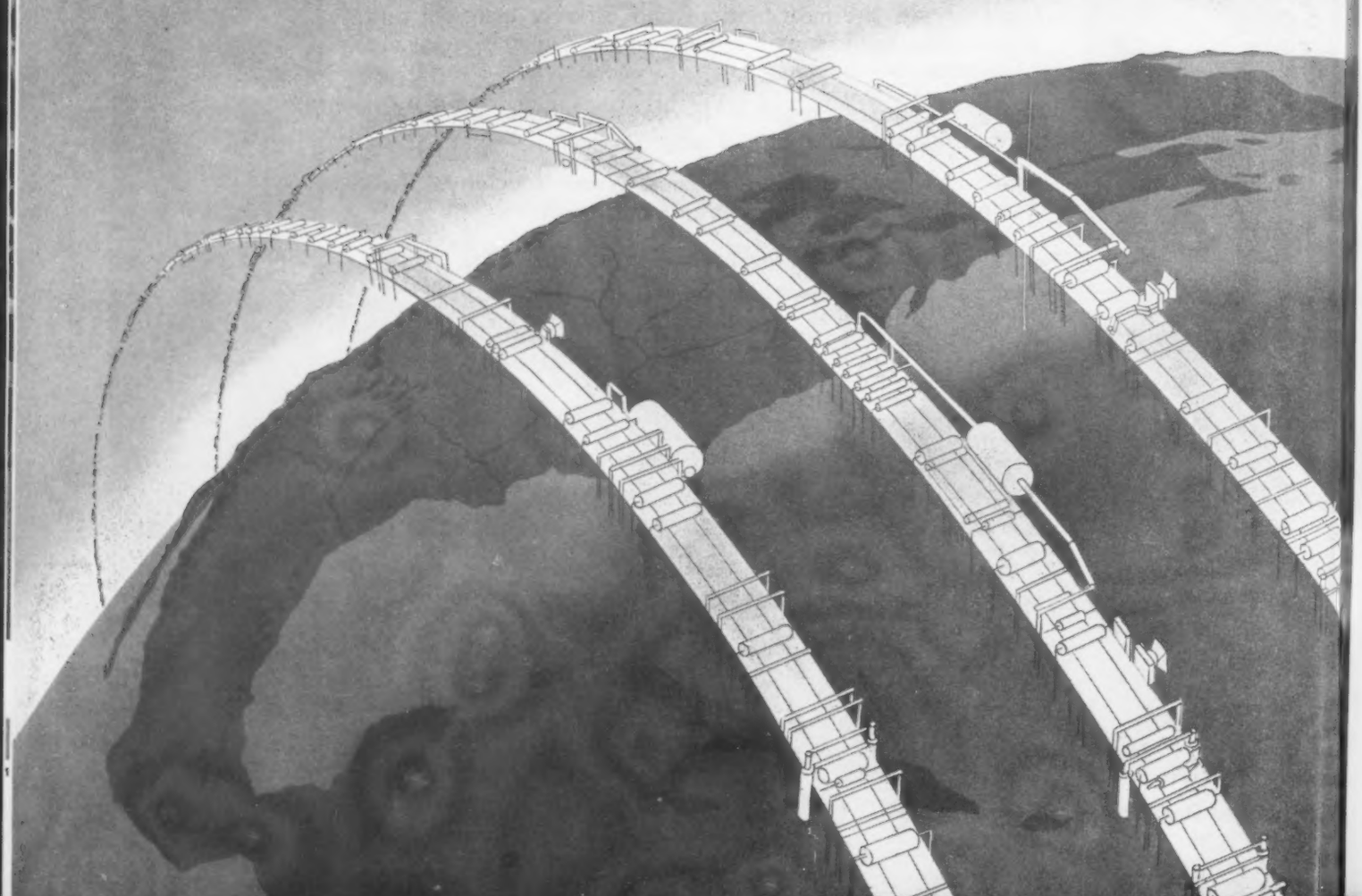

Armco Starts Company's Seventh Galvanizing Line

IN LINE with the resurgence of galvanized steel, Armco Steel Corp. recently started up a new continuous galvanizing line, the company's seventh unit of this type. Located at the Middletown plant, the new unit cost $8,500,000. It will handle strip 30 to 72 in. wide, 0.0299 to 0.1196 in. thick, in coils up to 50,000 lb. With an inside diameter of 24 in., coils may range 30 to 72 in. outside diameter. The line, 565 ft long, operates at speeds of 38 to 300 fpm, with maximum speeds of 400 fpm on the entry and exit end equipment. It can produce 30 tons per hr. Approximately 2100 ft of strip is required to thread the line.

Strip first passes through two oxidizing furnaces, 17 ft-6 in. long, wherein residual rolling oil is burned off and a thin oxide film is formed on the steel surface. Next is the 173-ft reducing and annealing furnace, where an atmosphere of dissociated ammonia reduces the oxide film. Cooling is controlled as the strip passes through a 200-ft cooling furnace.

Figure 1 — This new 72-in. continuous zinc-coating line, located at Armco Steel Corp.'s Middletown, Ohio, works, is the widest unit of its kind ever built. Now in full operation, the unit has an average capacity of 30 tons of zinc-coated steel per hr. The company now has seven coating lines in operation.

Next, the strip goes through a molten zinc bath, followed by a long cooling path up through the building trusses and finally, to the coiler. Radioactive gages employing strontium 90 are used to check the coating weight. If desired, the product may be cut into lengths of 5 to 20 ft. At present, about 45 per cent of Armco's coated sheet is shipped in coil form.

Armco began using the continuous galvanizing process, which was invented by Tadeusz Sendzimir and developed by Armco, in 1937 on a line at the Butler works. The process gives a coating of great adherence, so that the coated sheet can be drawn and formed without cracking, peeling or flaking. The process is also used in coating steel with aluminum.

The new line was designed to produce widths up to 72 in. for the benefit of consumers who might need wider sheet.

Armco has developed a variety of zinc-coated products with new surface finishes which it believes will stimulate the use of coated sheets in various markets. A differential coating can be furnished, with one side carrying a standard weight coating for full corrosion resistance, while the other side has a minimum coating for ease in painting.

There is a spangle-free, chemically treated surface with standard 1.25-oz coating for corrosion resistance but adaptable for painting.

There is also a new process to minimize but not eliminate spangle, for surface requirements falling between standard and spangle-free. ▲

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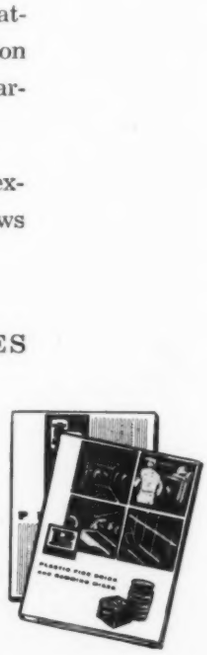

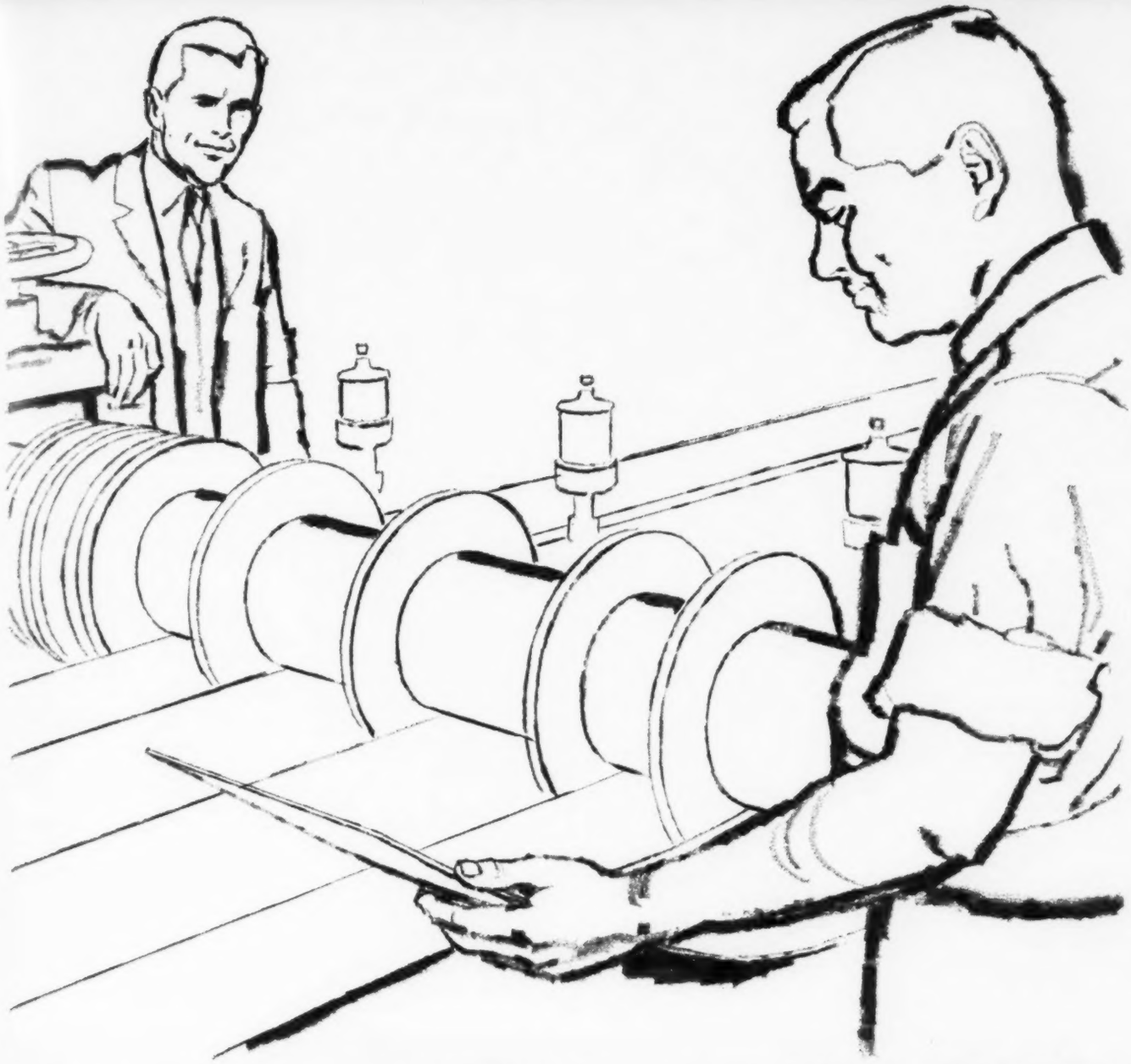

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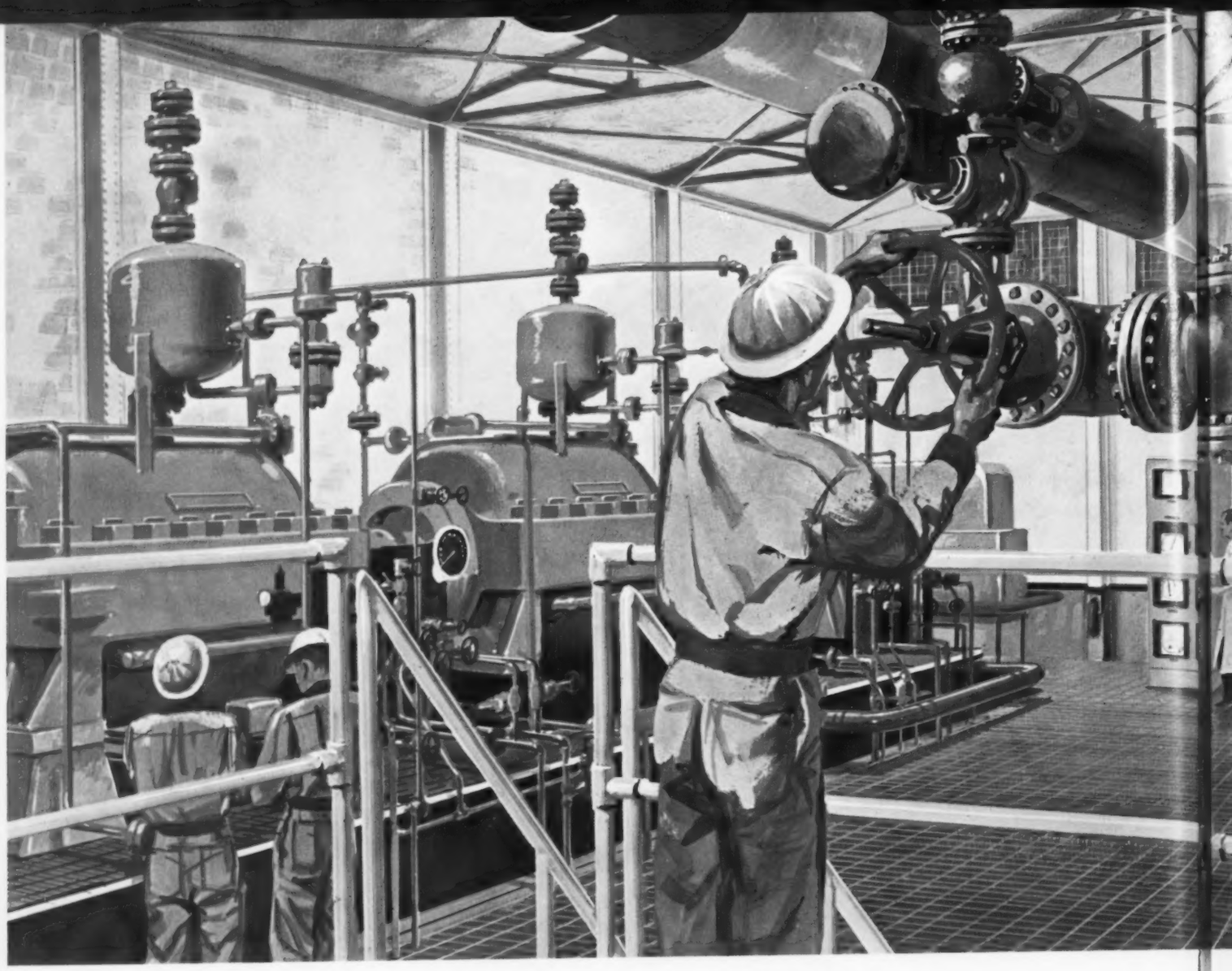

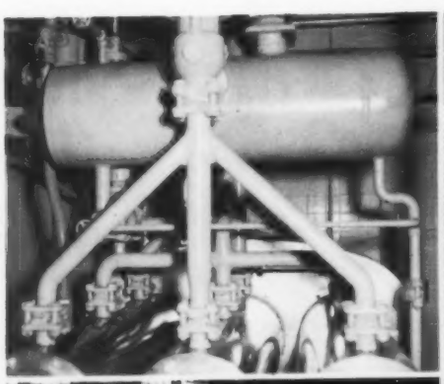

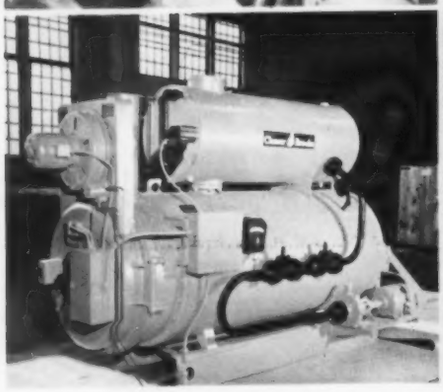

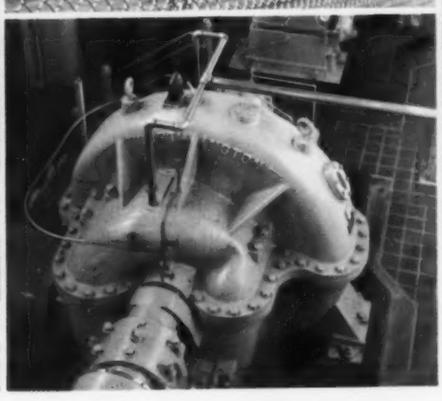

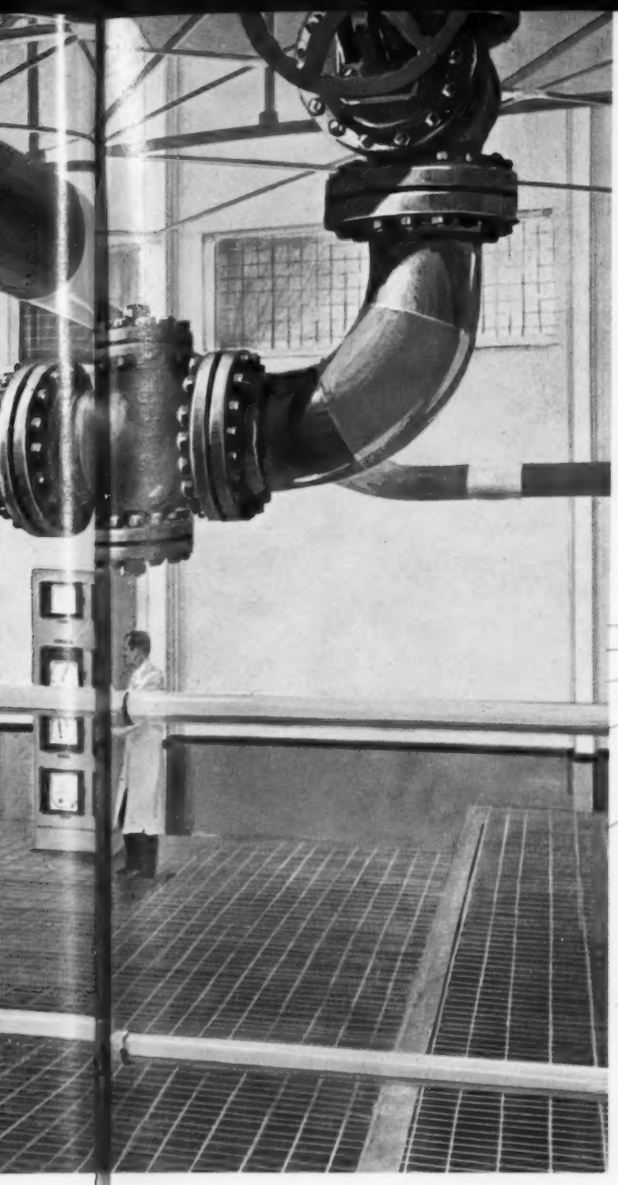

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HERE is a modern, functional *system* that combines four important points. (1) the ability to stop rust, (2) modern color harmony, (3) durability to last and last, (4) ease of application. From machinery, equipment, and structural steel to tanks, steel fences and metal sash – the Rust-Oleum New Color Horizons System can provide lasting beauty in the colors of your choice. Ask your Rust-Oleum Industrial Distributor, together with your Rust-Oleum Factory Specialist, to make a survey of your plant and provide complete recommendations. Rust-Oleum Industrial Distributors maintain complete stocks for prompt delivery in all principal cities of the United States, Canada, and in many countries around the world.

Rust-Oleum, in its various forms, can also save you time and money on problems like these: Heat Resistance, Water Resistance, Chemical Resistance, Coating Galvanized Metal, Speedy-Dry Coatings (less than thirty minutes to dry).

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Save time, money, and metal. Brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining sound rusted surface after scraping and wirebrushing to remove rust scale and loose rust. **Specially-processed** fish oil vehicle penetrates rust to bare metal as proved in radioactive tracing studies.

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- ☐ FREE TEST SAMPLE of Rust-Oleum 769 Damp-Proof Red Primer.
- ☐ Please have your representative contact us to discuss a plant survey.

Concrete for a penthouse

High above the street, a giant crane swings the bucket into place, concrete gushes from a spout, and workmen begin placing the floor for a structure to house elevator machinery. From its ample reserves of manpower, United Engineers can draw on a broad variety of skills and experience. Engineers, draftsmen, electrical workers, construction men—specialists in every category. All have behind them many years of working on construction projects of every size and type. Whatever the assignment—industrial building or steel mill, power, process or gas plant—we can assemble a crack team to handle it. The men who are United Engineers offer you a background of over 75 years' experience as designers, construction engineers, and engineering consultants.

Painting by Robert Lavin

Helping the steel industry grow

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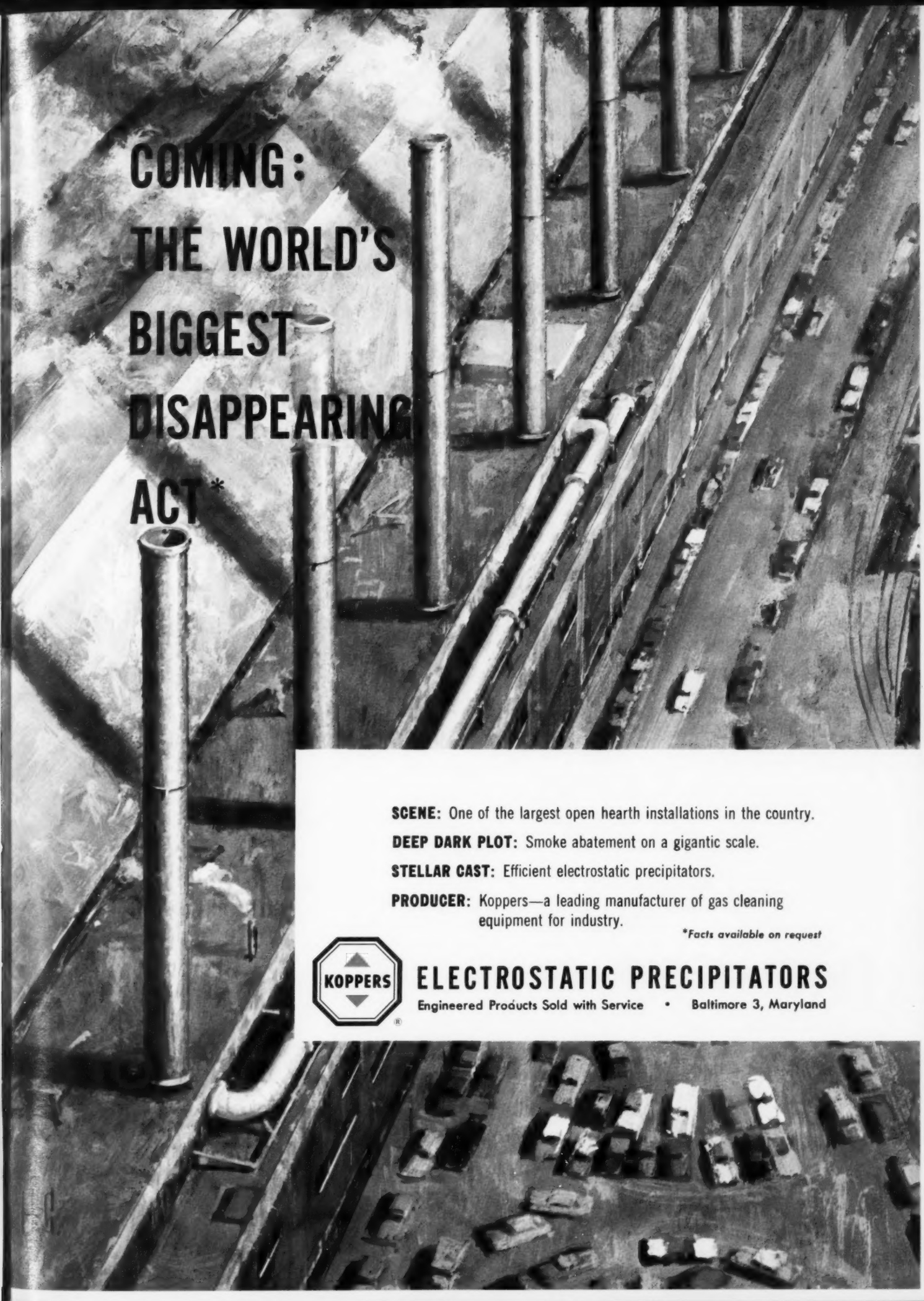

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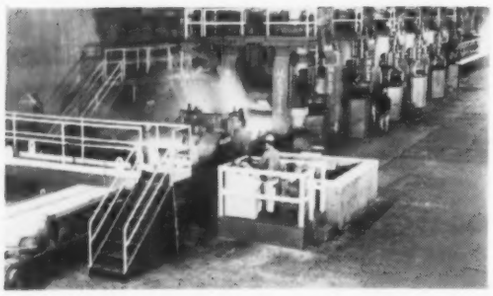
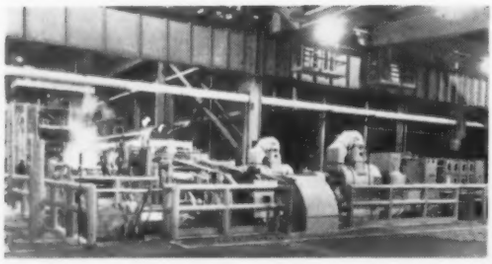
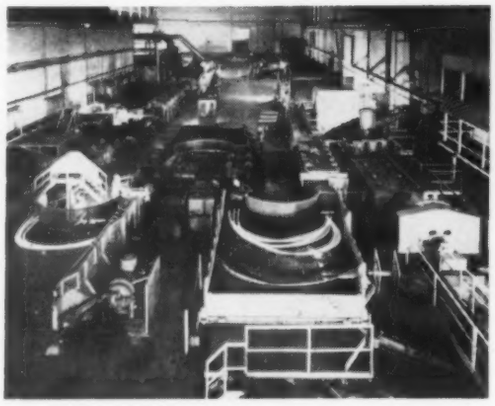
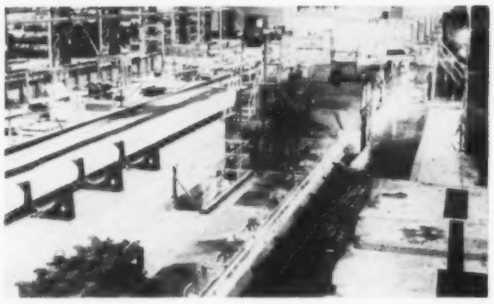
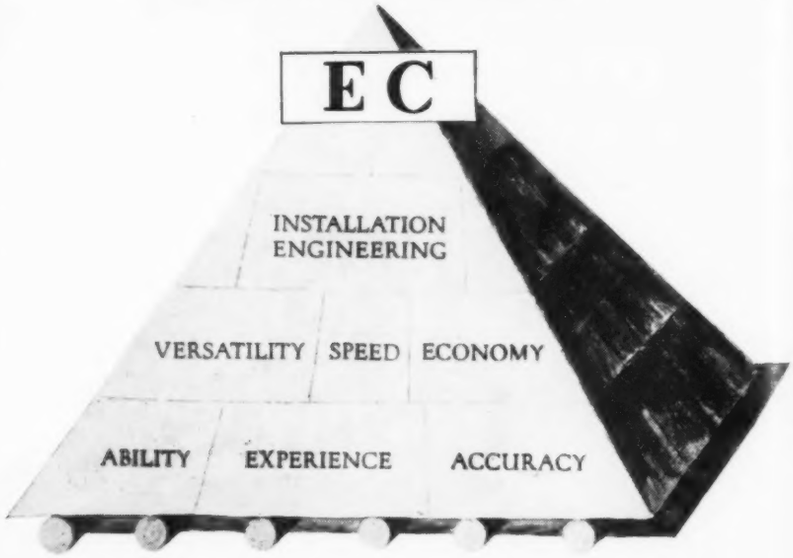


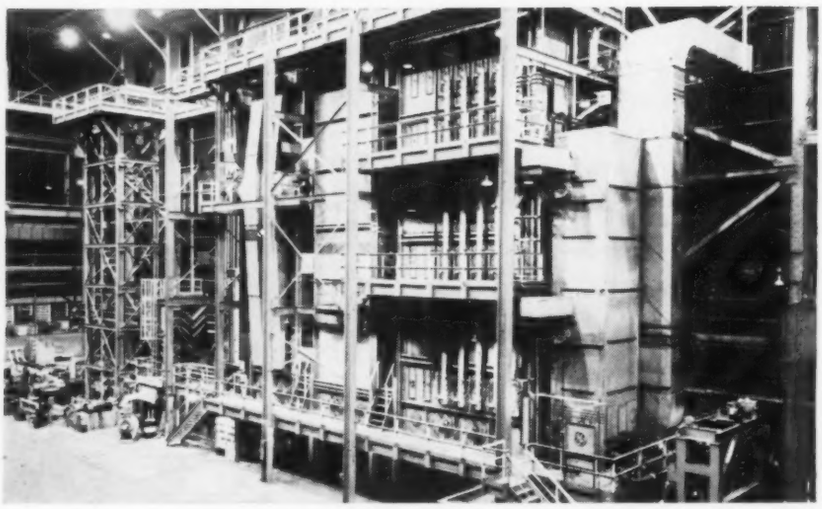






MECHANICAL Installations





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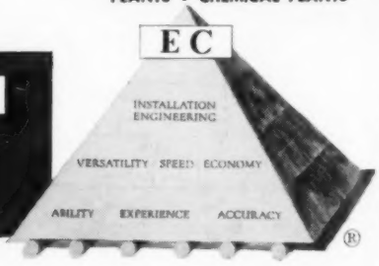

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Date-line Diary...

August 2

Δ Allis-Chalmers Mfg. Co. reported for the first six months of 1961 sales totaling $260,087,999, net earnings of $4,566,323 equal to 50¢ per share, compared with the first half 1960 sales totaling $284,499,708, net earnings of $7,585,979 equal to 83¢ per share.

Δ American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in July, 1961, totaled 9,249,270 tons, compared with 11,277,149 tons in July, 1960.

Δ Interlake Iron Corp. reported for the first six months of 1961 sales totaling $37,926,792, net earnings of $1,425,405, equal to 63¢ a share, compared with sales of $51,836,476, net earnings of $3,467,140 equal to $1.54 per share for the same period of 1960.*

August 3

Δ Central Steel & Wire Co., Chicago, reduced prices of galvanized steel sheet $8 to $12 a ton.

Δ The Bureau of the Census reports that shipments of iron and steel castings in May, 1961, totaled 1,153,930 tons compared with 1,018,800, tons in April, 1961 and 1,248,320 tons in May, 1960.

August 4

Δ The Dept. of Commerce reported that business inventories in manufacturing, wholesale and retail lines in June, 1961, rose to a seasonally adjusted $91,400,000,000; total business sales in June, 1961, increased to a seasonally adjusted $62,100,000,000, up $500,000,000 from May, 1961.

Δ American Iron Ore Assn. and AISI joint report for the second quarter of 1961 shows receipts of iron ore and ore agglomerates in the U. S. totaled 21,196,154 gross tons, compared with 40,302,584 tons in the same period of 1960; consumption in the second quarter 1961 totaled 23,970,512 tons compared with 28,232,760 tons in the same period of 1960. For the first half of 1961 receipts totaled 29,142,466 tons compared with 53,676,640 tons in 1960; consumption totaled 43,191,485 tons in 1961 compared with 63,214,278 tons in 1960.

Δ The AISI reports that the steel industry's payroll for hourly and salaried workers in June, 1961, totaled $321,075,715 compared to $326,162,209 in May, 1961. Total employed in June numbered 532,282, compared with 518,641 in May. Payroll cost per hr worked by hourly employees was $3.480 in June compared with $3.467 in May not including 47.1¢ per hr supplemental employee benefits. Average hours worked per week were 37.5 in June, 1961, compared with 38.3 in May, 1961.

Δ The Bureau of Mines reported that production of Pennsylvania anthracite in July, 1961, totaled 1,180,000 net tons, compared with 1,372,000 tons in June, 1961, and 1,186,000 tons in July, 1960.

August 5

Δ The AISI reports that production of steel for the week ending August 5, 1961, totaled 1,850,000 net tons (about 65.0 per cent of capacity) compared with 1,818,000 tons one week ago (63.5 per cent of capacity) and 1,537,000 tons one year ago. Index of production was 99.3.

* Net earnings per share (1961) corrected.

August 7

Δ The AISI reports that shipments of finished steel products for the first six months of 1961 totaled 31,227,998 tons, compared with 42,853,937 tons in the same period of 1960. Shipments in June, 1961, totaled 6,133,519 tons, compared with 6,047,691 tons in May, 1961, and 5,920,860 tons in June, 1960.

Δ The Bureau of Mines reports that consumption of scrap in June, 1961, totaled 4,946,000 gross tons compared with 5,333,515 tons in May, 1961, pig iron consumption in June, 1961, totaled 5,244,000 tons compared with 5,235,705 tons in May, 1961.

August 9

Δ The Dept. of Commerce reported that U. S. spending abroad for new plant and equipment in 1961 will climb to an estimated $4,500,000,000 and is 20 per cent higher than the 1960 expenditures.

August 10

Δ The Aluminum Assn. reports that shipments of aluminum sheet and plate in June, 1961, totaled 133,951,000 lb compared with 132,832,000 lb in May, 1961, and 127,216,000 lb in June, 1960. Shipments for the first six months of 1961 totaled 734,265,000 lb compared with 700,208,000 lb in the same period of 1960. Shipments of aluminum foil in June, 1961, totaled 21,098,094 lb compared with 20,039,338 lb in May, 1961, and 18,894,474 lb in June, 1960. Shipments for the first half of 1961 totaled 119,751,733 lb compared with 112,336,497 lb in the same period of 1960.

Δ The Bureau of the Census reports that production of titanium mill products in June, 1961, totaled 708,626 lb compared with 555,608 lb in May, 1961, and 903,620 lb in June, 1960.

Δ The Bureau of the Census reported shipments of commercial steel forgings in June, 1961, totaled 107,597 tons compared with 105,419 tons in May, 1961, and 110,103 tons in June, 1960.

August 11

Δ The Dept. of Commerce reported world steel production for the first half of 1961: (1) U. S., 44,900,000 tons, down 26 per cent from 1960; (2) Soviet Union, 38,400,000 tons, up nine per cent from 1960; (3) West Germany, 19,000,000; (4) Japan, 14,600,000, up 26 per cent over 1960; (5) Great Britain, 13,700,000, down a shade from 1960. Total production amounted to 182,000,000 tons, down four per cent from the 1960 total.

Δ The Labor Dept. reported that nonfarm employment in mid-July, totaled 53,198,000, down 169,000 from the mid-June level, less than the normal decline.

Δ The AISI reported that production of ingots and steel for castings during July, 1961, totaled 8,090,000 net tons, compared with 8,551,856 tons in June, 1961, and 6,350,924 tons in July, 1960.

August 12

Δ The AISI reports that production for the week ending August 12, 1961, totaled 1,910,000 net tons (about 67.1 per cent of capacity) compared with 1,850,000 tons one week ago (65.0 per cent of capacity) and 1,525,000 tons one year ago. Index of production was 102.5.

August 15

Δ The Bureau of Mines reported that production of

pig iron in the U. S. for 1960 totaled 66,501,000 tons compared with 60,210,000 tons in 1959; shipments totaled 65,612,000 tons in 1960 compared with 61,245,000 tons in 1959. Production of steel ingots and castings in 1960 totaled 99,282,000 tons, compared with 93,446,000 tons in 1959. World production of pig iron in 1960 totaled 285,000,000 tons, compared with 247,000,000 tons in 1959; steel ingots and castings in 1960 totaled 381,200,000 tons compared with 336,400,000 tons in 1959.

August 16

Δ Carpenter Steel Co. reports, for the year ending June 30, 1961, sales totaling $66,120,982, net earnings of $3,313,318 equal to $1.75 per share compared with sales totaling $85,077,787, net earnings of $6,571,012, equal to $3.50 per share for the fiscal year ending June 30, 1960.

August 17

Δ The U. S. balance of payments deficit for the second quarter of 1961 rose to $450,000,000 from the first quarter's $288,000,000 yet it was less than the $706,000,000 deficit in the second quarter, 1960.

Δ The Dept. of Commerce reported that personal income in July, 1961, rose to the annual rate of $421,800,000,000, an increase of $4,500,000,000 over the June, 1961, rate, and $17,100,000,000 over the July, 1960, annual rate.

Δ Resistance Welder Manufacturers Assn. report that shipments by members in July, 1961, amounted to more than $2,500,000; new orders received during July totaled more than $2,000,000. Backlogs at the end of July were reported in excess of $7,000,000.

August 18

Δ The Commerce Dept. reported imports of 277,000 tons of steel in June, 1961, up 11,000 tons from May, 1961; exports of steel in June, 1961, amounted to 146,000 tons, down 13,000 tons from May, 1961.

Δ The Commerce Dept. reported that new orders received by durable goods makers in July, 1961, rose to a seasonally adjusted $15,200,000,000, two per cent above June, 1961. Sales in July, 1961, rose to a seasonally adjusted $14,900,000,000, one per cent above June, 1961.

August 19

Δ The AISI reports that production of steel for the week ending August, 19, 1961, totaled 1,944,000 net tons (about 68.3 per cent of capacity) compared with 1,910,000 tons one week ago (67.1 per cent of capacity) and 1,558,000 tons one year ago. Index of production was 104.4.

Δ The Japan Iron & Steel Federation reports that production of pig iron in Japan in June, 1961, totaled 1,455,300 tons; ingot steel 2,601,500 tons.

Δ American Iron Ore Assn. and AISI joint report indicates that receipt of iron ore agglomerates in the United States in July, 1961, totaled 12,680,833 gross tons, compared with 15,705,014 tons in July, 1960; consumption in July, 1961, totaled 8,517,650 tons compared with 7,014,496 tons in July, 1960. Blast furnaces in operation as of July 31, 1961, totaled 140 of the existing 255. On July 31, 1960, 138 blast furnaces were operating.

Δ The ARCI reported that deliveries of new freight cars in July, 1961, totaled 1229 compared with 3142 in June, 1961, and 3893 in July, 1960. Orders in July, 1961, totaled 2452 compared with 1214 in June, 1961 and 1306 in July, 1960. Backlog of cars on order as of August 1, 1961, totaled 10,644, compared with 11,821 on July 1, 1961 and 26,658 on August 1, 1960.

August 21

Δ The Bureau of the Census reports that net shipments of aluminum mill products in June, 1961, amounted to 304,395,000 lb, compared with May, 1961, shipments of 295,257,000 lb. Shipments of magnesium mill products in June, 1961, totaled 1,700,000 lb compared to 1,815,000 lb in May, 1961.

Δ The Bureau of the Census reported that housing starts in July, 1961, were at a seasonally adjusted annual rate of 1,317,000 units, five per cent below the June, 1961, rate, but seven per cent over the July, 1960 pace.

Δ The Commerce Dept. reported that personal income in 1960 averaged $2223, up $63 from the 1959 figure.

August 22

Δ The Aluminum Assn. reports that production of primary aluminum in the U. S. in June, 1961, totaled 164,733 tons, compared with 159,092 tons in June, 1960, and 177,564 tons in July, 1960.

August 25

Δ The AISC reports that bookings of fabricated structural steel in July, 1961, totaled 456,332 tons, compared with 297,555 tons in June, 1961, and 302,154 tons in July, 1960. Shipments in July, 1961 totaled 286,917 tons, compared with 361,159 tons in June, 1961, and 338,860 tons in July, 1960. Backlog on July 31, 1961 was 2,517,052 tons.

Δ The Bureau of the Census reports that shipments of nonferrous castings in June, 1961, totaled 180,367,000 lb, compared with 182,408,000 lb in May, 1961.

August 26

Δ The AISI reported that steel production for the week ending August 26, 1961, totaled 2,020,000 net tons (about 70.7 per cent of capacity) compared with 1,944,000 tons one week ago (68.3 per cent of capacity) and 1,547,000 tons one year ago. Index of production was 108.4.

August 28

Δ F. W. Dodge Corp. reported that total construction contracts in the U. S. in July, 1961, totaled $3,528,553, compared with $3,596,909 in July, 1960. According to the Dodge Index (1947–49 = 100) July, 1961, 277; June, 1961, 281; July, 1960, 285.

August 29

Δ National Machine Tool Builders Assn. reports that net new orders of cutting and forming type machine tools in July, 1961, totaled $55,950,000 compared with $61,500,000 in June, 1961; shipments in July, 1961, totaled $51,100,000, compared with $64,200,000 in June, 1961.

Δ The Labor Dept. reported that consumer prices in July, 1961, rose to 128.1 per cent (1947–1949 average 100 per cent) up 0.4 per cent from June, 1961.

August 30

Δ The Bureau of the Census reported that construction spending in August, 1961, was at a seasonally adjusted annual rate of $58,300,000,000, one per cent above the July, 1961, rate.

August 31

Δ President Kennedy urged steel companies to avoid price increases this fall, stating that he believed the companies could absorb October wage increases and still have fair profit levels.

Δ The Commerce Dept. reported that manufacturers orders in July, 1961, rose slightly to a seasonally adjusted $31,200,000,000.

Δ The Bureau of the Census reported that U. S. exports in July, 1961, seasonally adjusted, amounted to $1,707,200,000, seven per cent above June, 1961.

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Heavy, pure aluminum, inseparably atomic-welded to a strong steel core—that's Alumoweld wire, used extensively today in the power and communications fields. And all of this valuable product is drawn rapidly, economically and dependably on VAUGHN Motoblox machines—whether destined for use as telephone line wire, overhead ground wire, core wire for ACSR conductors, guy and messenger strand or other essential and money-saving applications. ● Whatever the wire, rod, bar or tube, there's a VAUGHN machine to draw it profitably. Write us!

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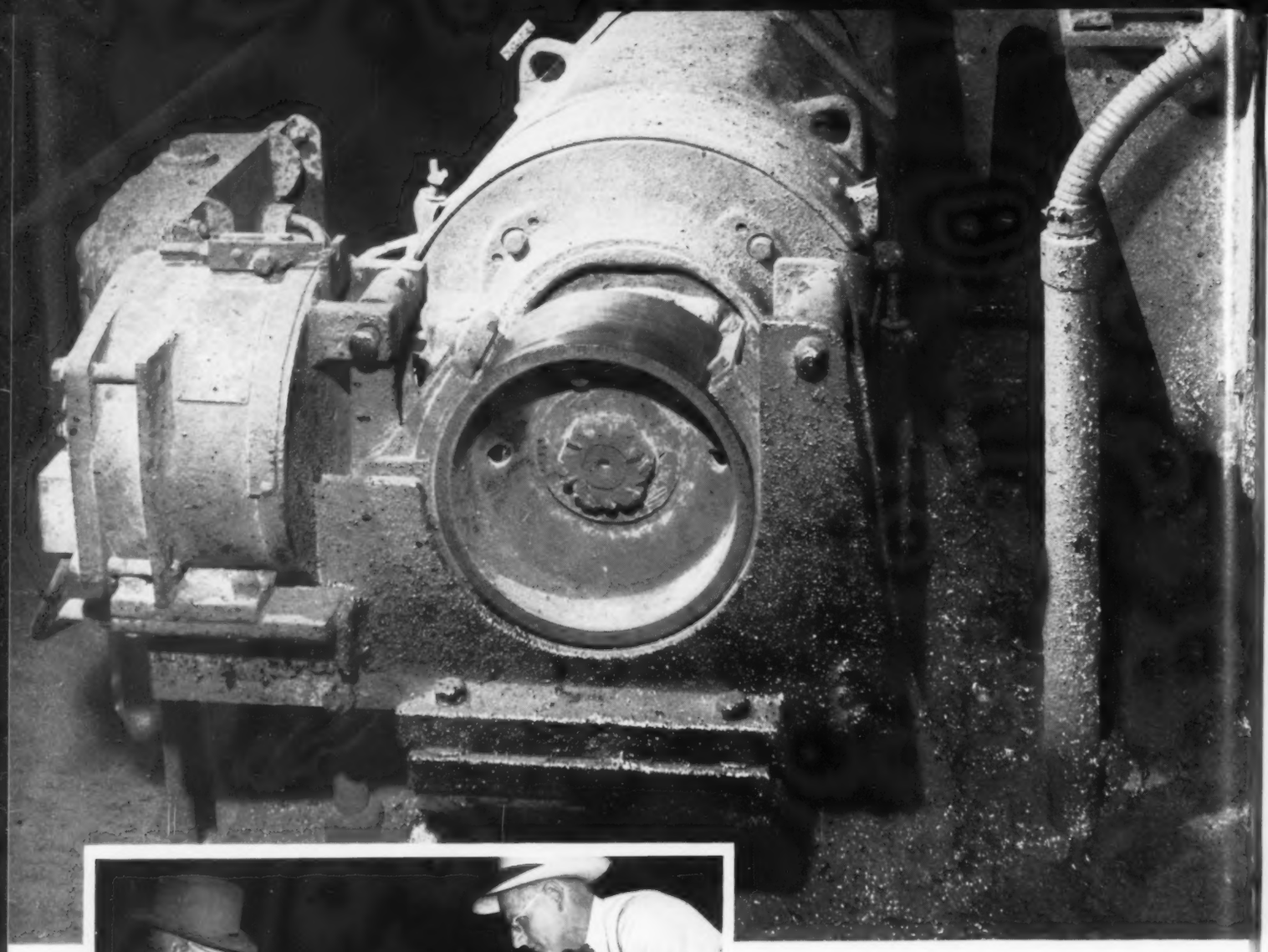
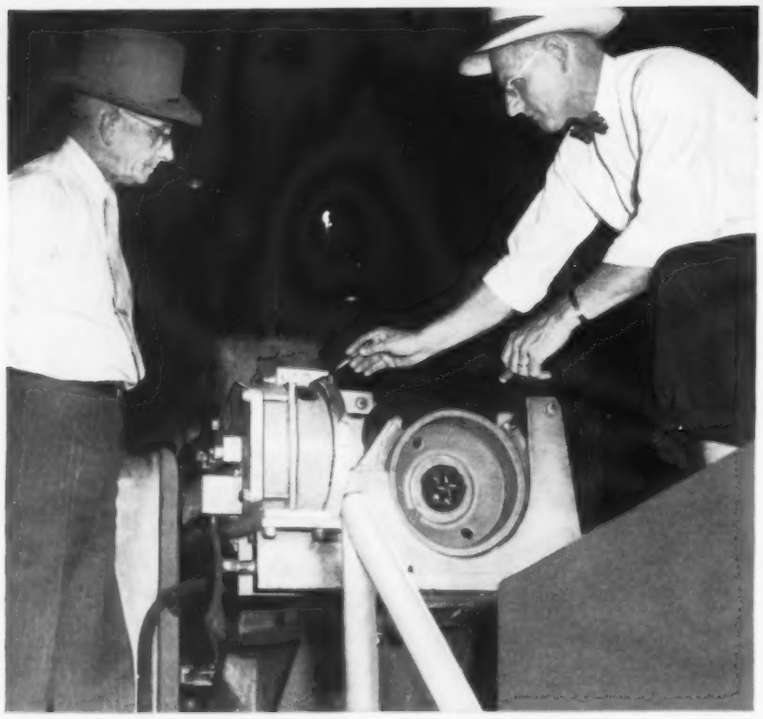




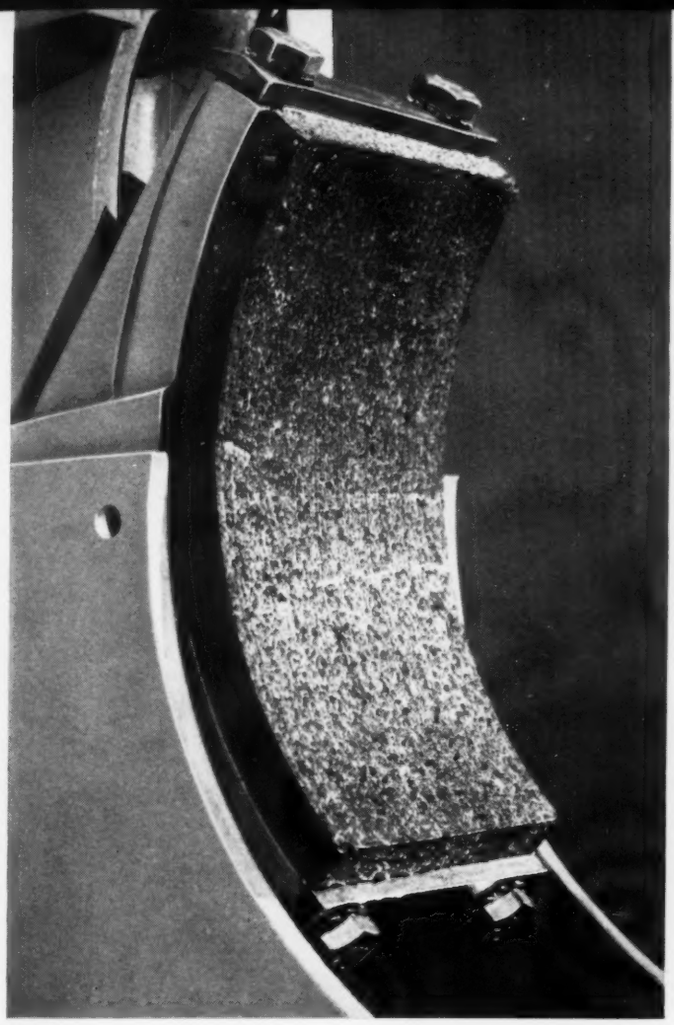
This General Electric d-c brake has been at work for seven years! In 1954, it was installed on a slab depiler at the Jones & Laughlin Steel Corp., Cleveland. Lower photo shows the brake shortly after installation. Top photo was taken just a few weeks ago. It's the same brake! J&L reports that the only maintenance ever required has been occasional adjustment to compensate for shoe wear, and replacement of normal wear parts.

GENERAL ELECTRIC'S

Seven

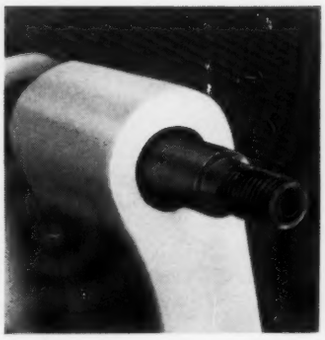
In 1954, General Electric introduced the first d-c magnet brake designed and built to NEMA-AISE standards. This two-shoe, single-magnet, single-armature brake responds rapidly to prevent load slippage or coasting after motor power is cut off.

In seven years, this General Electric brake has been put to work on industry's toughest jobs—rolling mills, cranes, ore unloaders . . . all types of equipment requiring positive stopping and holding of heavy loads. Hundreds

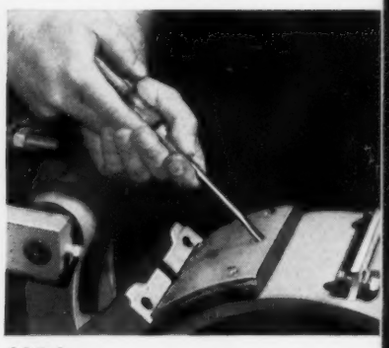


1961 Just announced: Bonded linings now replace riveted linings—exclusively on G-E d-c brakes. Result is 50% longer life due to greater braking surface, thicker usable lining. Rivet-scored wheels are a thing of the past. And bonding is five times stronger than riveting formerly used!

1960 Complete magnet housing replacement is accomplished in minutes. Both magnet and coil remove vertically or horizontally without disturbing linkage or settings.



1956 Self-lubricating sintered-brass bearings eliminate need for periodic greasing. Now, in 1961, they're sealed to keep out damaging dirt.



1954 Slip-out brake linings remove easily with screwdriver after removal of only two holding bolts. No torque readjusting needed.

AMAZING DC MAGNET BRAKE

years of sure stops

of users attest to its positive performance, outstanding reliability, unusually low maintenance.

CONTINUED DESIGN IMPROVEMENT

Yet, General Electric engineers have never stopped development work on the d-c brake. Year by year, new, thoroughly tested features have been added . . . many readily adaptable to brakes already in service. Several features of today's G-E brake are pictured. Here are other important user benefits:

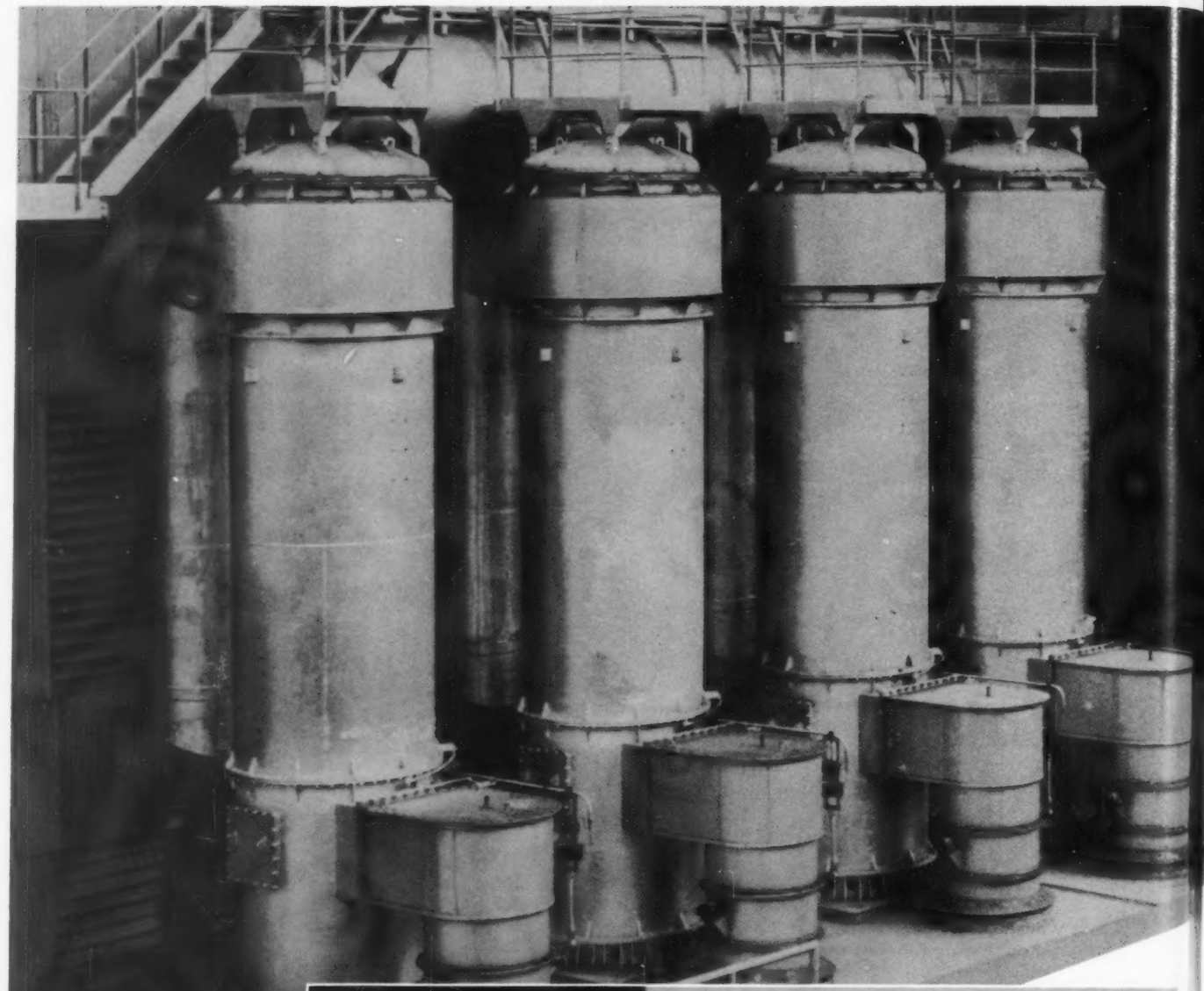
- Dust and grit simply fall through the new cutaway armature—greatly reducing downtime for cleaning.
- Damaging dust can't get through new rubber "O" rings around bushings.
- Higher temperature ratings, greater mechanical and dielectric strength are inherent in the epoxy-encased coil.
- Both the wheel and the brake linings are removable without energizing the brake or re-adjusting torque, by engaging the manual-release mechanism.
- Indication of lining wear takes only a glance at the armature-gap indicator.
- Shoe clearance and armature gap can be set from adjustments on one end.

If you have a job for a d-c brake or are planning one, let your G-E Sales Engineer show you why General Electric's amazing d-c magnet brake is by far your best buy. Or, write to Section 784-29, General Electric Co., Schenectady 5, N. Y.

Industry Control Dept., Salem, Va.

Progress Is Our Most Important Product

GENERAL ELECTRIC



selection

Broad choice of standard designs, with specialized Recuperators developed to your needs. No need to accept "same old design," regardless of application.

performance

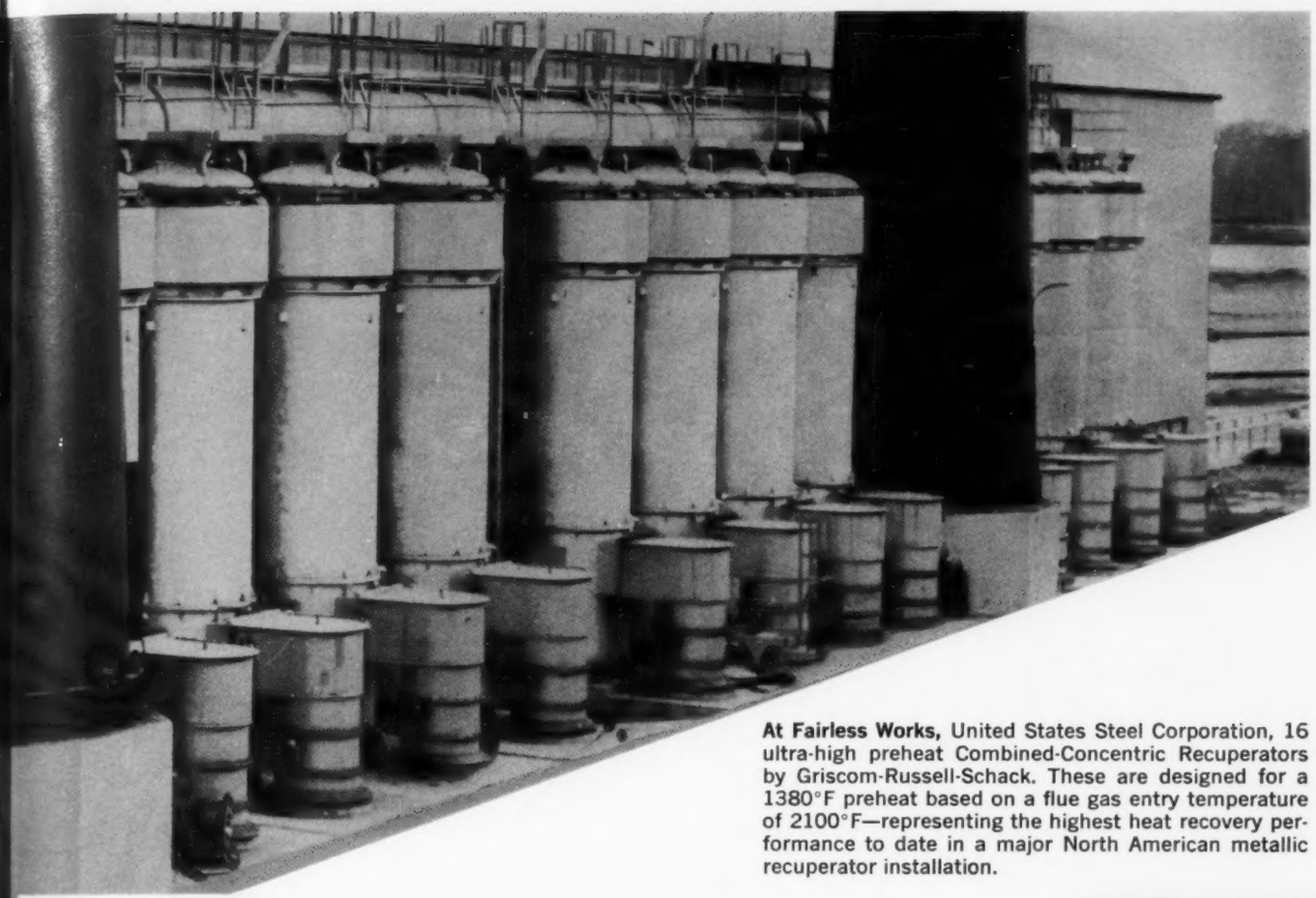
Designs will deliver preheat temperatures as high as 1500°F. Some types in continuous service for 15 years; with temperature efficiencies to 80%.

experience

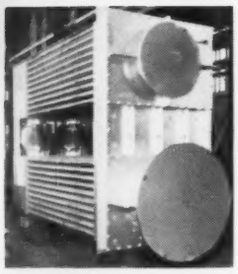
World's broadest Recuperator experience by far—more than 30 years of world-wide steel industry service.

Schack affiliates throughout the world now supply approximately 50% of all recuperators bought by the basic iron and steel industry.

GRISCOM-RUSSELL-SCHACK RECUPERATORS



At Fairless Works, United States Steel Corporation, 16 ultra-high preheat Combined-Concentric Recuperators by Griscom-Russell-Schack. These are designed for a 1380°F preheat based on a flue gas entry temperature of 2100°F—representing the highest heat recovery performance to date in a major North American metallic recuperator installation.

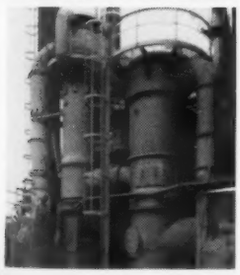


Problem: Positioning the recuperator in the flue between furnace and stack.

Solution: G-R-S Canal Recuperator—a simple, inexpensive construction, applicable to many applications.

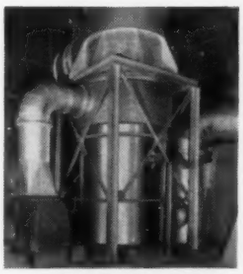
Problem: Handle gases at extremely high temperatures, without temperature dilution.

Solution: G-R-S Radiation Recuperator—available in parallel flow, counter flow and combination air flow arrangements; designed for most severe conditions.



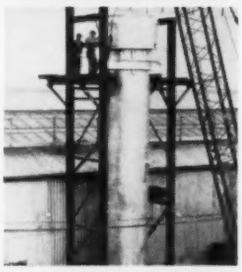
Problem: Providing air preheats to 1400°F, with compact, self-contained unit.

Solution: G-R-S Combined Concentric Recuperator—the ultimate in heat recovery performance; self-protecting to a considerable degree; requiring only minimum protection, instrumentation and controls. *Illustrated, a Combined-Concentric unit combined with a blast furnace gas Recuperator.*



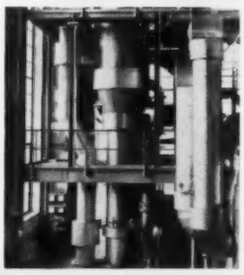
Problem: Severe dust carry-over—in soaking pit, continuous furnace and cupola applications.

Solution: G-R-S Flue Tube Recuperator—including individual tube expansion joints, special tube sheet cooling and other refinements.



Problem: Using a recuperator to eliminate the conventional stack.

Solution: G-R-S Stack Recuperator—available in many designs, with and without convection section at waste gas outlet end. Either self-supporting or structurally mounted.



Problem: High-pressure, high-temperature gas heating—natural gas, oxygen, carbon monoxide, hydrogen or steam.

Solution: G-R-S Fired Heater—many standard and special types, all complete with combustion chamber, burner, controls and instrumentation.

BROCHURES AVAILABLE ON ALL TYPES OF RECUPERATORS

THE GRISCOM-RUSSELL-SCHACK CO., INC.
RECUPERATORS MANUFACTURED IN MASSILLON, OHIO

MAIN OFFICE: 901 RIDGE AVENUE
PITTSBURGH 12, PENNSYLVANIA

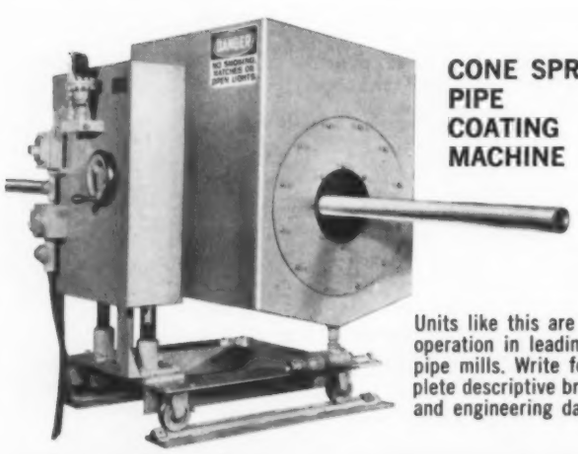
CONE SPRAY COATING

DEVELOPED BY PROTECTIVE COATING EXPERTS, this Cone Spray Coating system offers a degree of automation in production line application of clear coating materials never available before. You have the option of having Cleanola Company engineers design a complete system, or incorporating these precision-designed elements into your own equipment.

for PIPE.... for many other applications requiring:

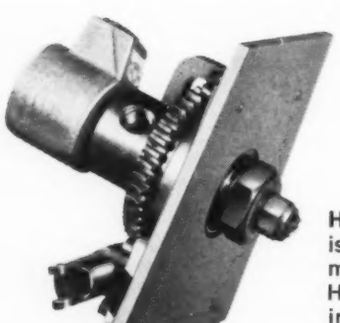
UNIFORMITY OF COATING,
virtually without overspray, regardless of pipe size or production speed.

COATING QUALITY CONTROL
through elimination of re-circulation of material, or other contamination.



CONE SPRAY PIPE COATING MACHINE

Units like this are now in operation in leading U. S. pipe mills. Write for complete descriptive brochure, and engineering data.



Heart of the system is this patented automatic Cone Spray Head, available either in movable or fixed design.

THE CLEANOLA COMPANY

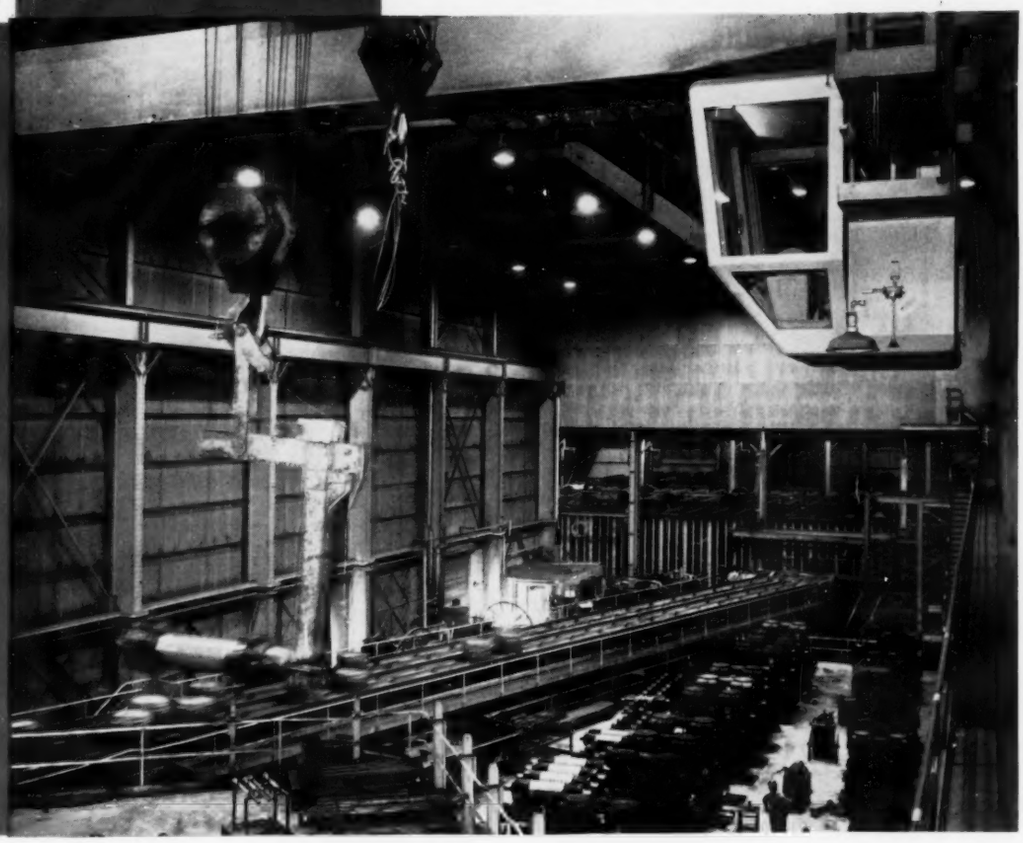
manufacturers of
PROTECTIVE COATING EQUIPMENT

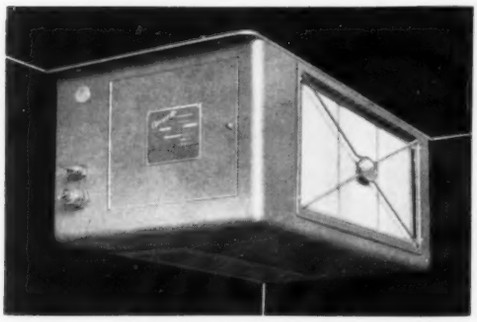
1116 WILLIAM FLYNN HIGHWAY
GLENSHAW, PA. • Phone HUNTER 6-7600

Correct-Air = 5

It ❶ cools, ❷ dehumidifies, ❸ removes dust, ❹ absorbs fumes and gases, ❺ heats

Patent Pending





Split and Self-contained systems, Water-cooled and Air-cooled, with conditioners for any location, add up to the most diversified line of heavy duty air conditioning offered today. From top to bottom: floor conditioner; seat-type conditioner; ceiling conditioner. In addition, Wall and Exterior-mounted conditioners complete another ***"5"***, making Correct-Air the only builder with 5 basic installation styles.

Invest in This Proven Aid to Maximum Production

Raise human efficiency in hot spots to the level of your mechanical progress. Give your men clean, healthful air summer and winter. Watch the improvement in operator alertness and safety; enjoy better industrial relations. You'll be repaid many times over.

Correct-Air's many models can be adapted to your exact conditions and requirements. A thorough Correct-Air analysis is gratis for the asking. Also, write today for your copy of Bulletin 2001-E.

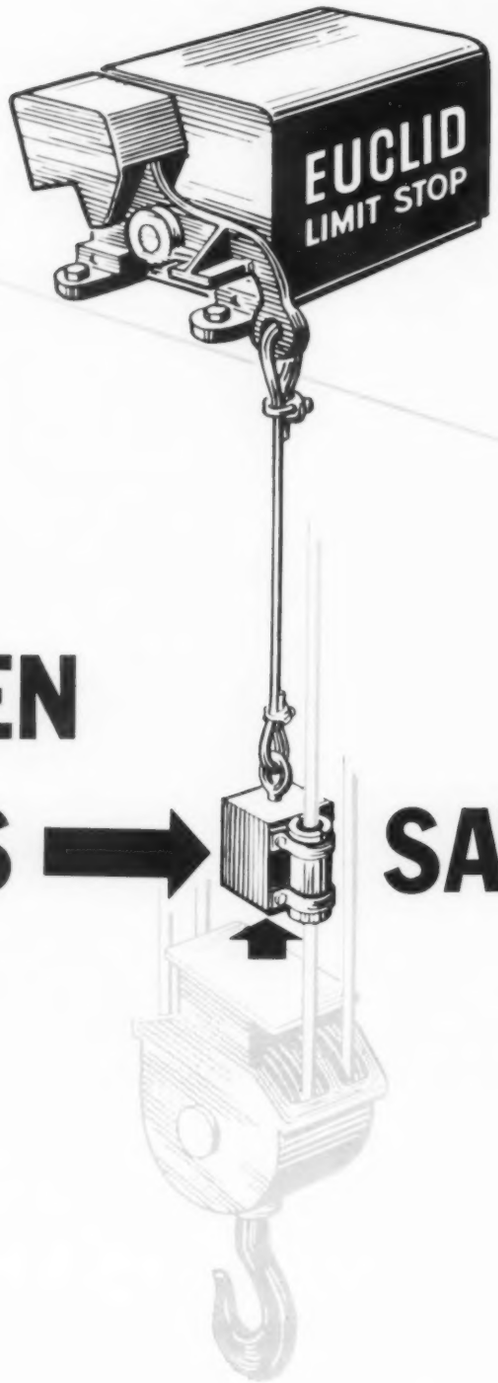
Correct-Air

CORRECT-AIR CORPORATION

Sold by **JAMES CAMPBELL SMITH, INC.**
Both of **WILLOUGHBY, OHIO**

Also, America's largest builders of air-conditioned pulpits and crane cabs

JCS



WHEN THIS → SAYS STOP the Hook Block STOPS!

Safe

No danger of overhoisting disasters (particularly damage to the trolley frame or hoisting mechanism) when it's EUCLID.

Simple

Tripping and reset weights do the job. Positive trigger action is assured when it's EUCLID.

Sure

Because this Crane Power Safety Limit Stop is EUCLID designed, tested, engineered and field proved.

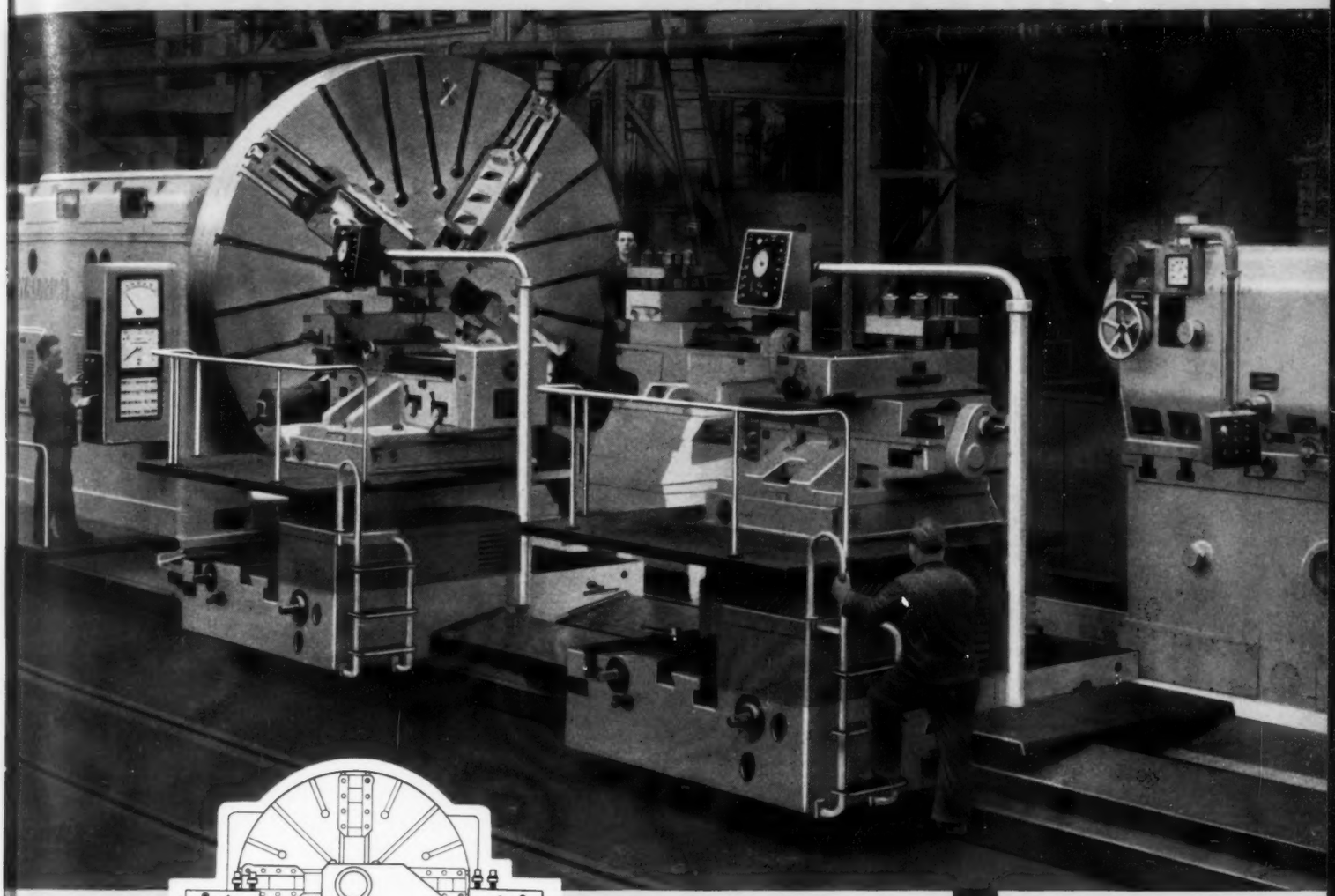
For more information about this heavy-duty, smaller in size, lighter in weight Limit Stop, ask for Bulletin 2130.

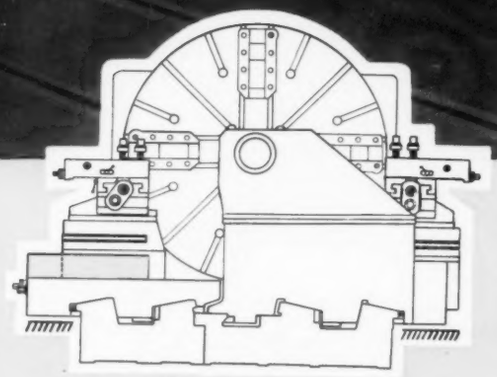
EX-28

We specialize in designing the control system best suited to your individual needs. Our services are yours for the asking. **CUSTOM ENGINEERING IS OUR BUSINESS. WHAT'S YOUR PROBLEM?**

The EUCLID Electric & Mfg. Co.
Dept. A • MADISON, OHIO

For the manufacturer of large equipment...





WALDRICH-SIEGEN LATHES

to 16′ swing and 66′ B.C.
All prismatic ways for long life and accuracy.
Extremely heavy design for maximum chip removal.
All functions controlled from the pendant at any saddle.

NEW

Feed case design permits the mounting of the bed in pit with ways on floor level for easy accessibility of the machine.

AMERICAN WALDRICH MFG. CORP.
1232 Penn Avenue, Pittsburgh 22, Pa.
HEAVY MACHINE TOOLS

WALDRICH SIEGEN

H. A. WALDRICH G.M.B.H.
SIEGEN • GERMANY

FALK INTRODUCES 2 NEW SERIES OF VERSATILE SPEED REDUCERS

Designed to serve industry's current and future requirements

Type YB
Right Angle Horizontal
(write for Bulletin 2100)

Type Y Parallel Shaft
(write for Bulletin 1100)

Parallel Shaft and Right Angle Horizontal Reducers cataloged thru 1,570,000 lb-in. torque at low speed shaft ...larger units upon request. Ratios 1.84 thru 292 to 1 for parallel shaft; 5.06 thru 1207 to 1 for right angle horizontal

These new units are probably the most thoroughly engineered speed reducers on the market today. Final designs based upon years of development study and a background of 50 years experience make these units as dependable as the name "FALK". A few of their many features are...

PINPOINT APPLICATION COVERAGE Wide choice of sizes and ratios permits the most economical selection of a correctly rated unit for each application. In each series of parallel shaft and right angle reducers, cataloged sizes range up to 1,570,000 lb-in. torque at the (11 inch dia.) low speed shaft. (Other standard designs to 25,000,000 lb-in. torque; custom designs for higher capacities.)

UNMATCHED VERSATILITY The "Basic Y" speed reducer design permits economical modification to meet a multitude of specific requirements. Smooth, flat surfaces simplify mounting of motor brackets, backstops, brakes, and any number of other accessories.

RUGGED HOUSINGS Sturdy housings not only provide maximum rigidity to maintain proper alignment of gearing, but also have the strength to support heavy overhung loads and withstand accidental blows.

DEPENDABLE FALK GEARING Gears are selected with the proper proportions and hardness to provide the optimum combination of maximum durability and strength for high shock as well as uniform loads.

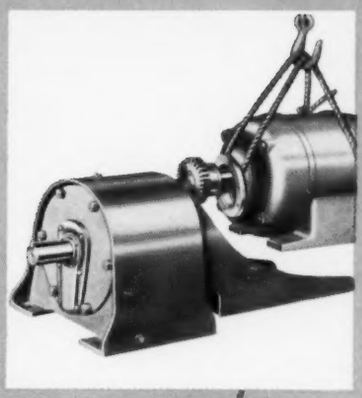
BEARINGS TO SUIT THE OVERHUNG LOAD Standard reducers can meet custom-built requirements with optional stock bearings and shafts (at only a nominal extra charge.) Maximum overhung load capacities are so great that for some conditions, still within the capacity of the reducer, extra strong supporting foundations and bolts must be provided.

DOUBLE GEAR LIFE Standard double ended shafts can be reversed end for end to bring into contact the unused surfaces of the gear teeth for twice the normal gear life.

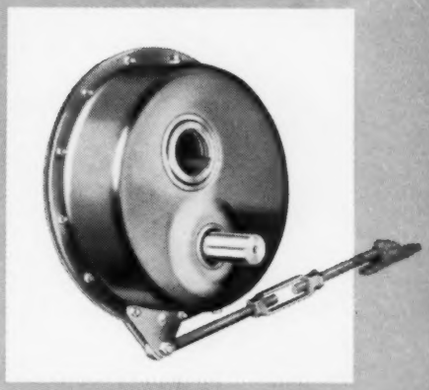
SEALS FOR ALL CONDITIONS Standard equipment oil seals assure oil-tight and dirt-free gear units for normal applications. Standard abrasive and moisture-resistant seals available upon order.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN
MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS
Representatives and Distributors in most principal cities

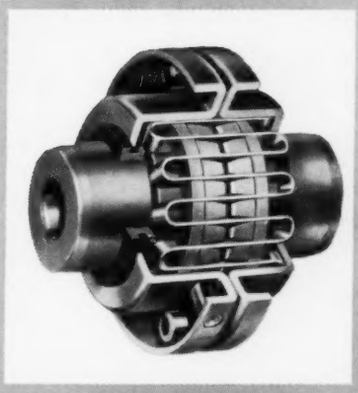
SOME OTHER MEMBERS OF AMERICA'S FIRST FAMILY OF POWER TRANSMISSION PRODUCTS



ALL-MOTOR MOTOREDUCERS



SHAFT MOUNTED DRIVES



STEELFLEX COUPLINGS

FALK

A GOOD NAME IN INDUSTRY

FALK, ALL-MOTOR, and STEELFLEX are registered trademarks

TRANSFERS - DEPILERS - PUSHERS
For 40,000 lb. Slabs at Youngstown Sheet & Tube Co.

Designed and built by

PITTSBURGH

ENGINEERING & MACHINE DIVISION

pittsburgh steel foundry • a Textron company

Electric and open hearth steel castings from 1 lb. to 100 tons

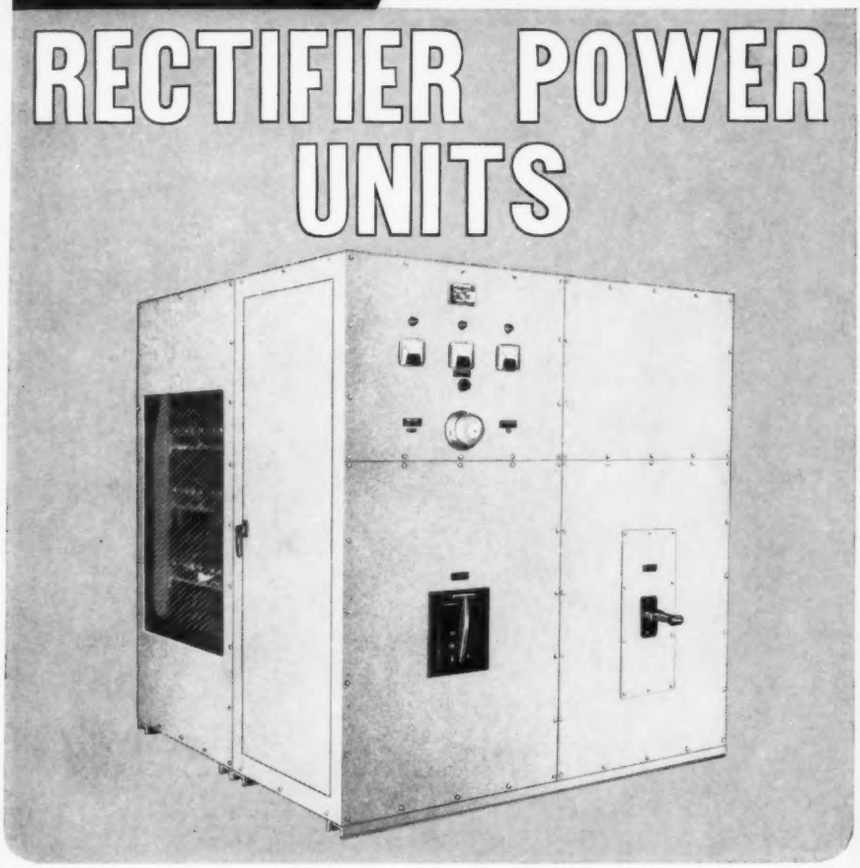
564 FORBES AVE., PITTSBURGH 19, PA. • PLANTS AT GLASSPORT AND McKEESPORT, PA.

economical a-c to d-c power supplies

SYNTRON

SILICON or SELENIUM

RECTIFIER POWER UNITS



lower operating costs, lower maintenance cost, high efficiency 92 to 95%.

Syntron Rectifier Power Units cover a full range of industrial d-c power needs from 100 KW to 5000 KW for any standard d-c output voltage and a-c input voltage both in unregulated and regulated types. Units can also be supplied with variable voltage for controlling a variable speed d-c motor with armature and field control.

Syntron's own field proven, time tested Selenium or Silicon Rectifiers make it possible to build power units that out-perform older, more expensive power conversion equipment. Higher efficiency — Selenium 83 to 85% at full load and Silicon 92 to 95% at full load. High power factor expected 92 to 97.5%.

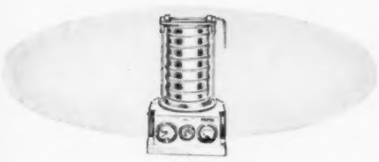
Syntron Rectifier Power Units are single, compact, self-contained units that cost less, are easy to install, require less floor space, lower operating cost, offer longer life, and practically no maintenance.

For greater economy, efficiency, and dependability on any industrial d-c power application insist on Syntron Rectifier Power Units designed for industrial applications, each according to specific power requirements.

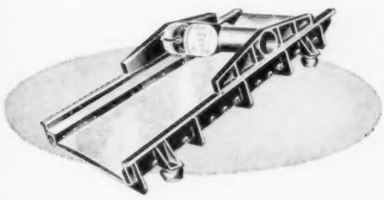
Write today for detailed technical information.

SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON

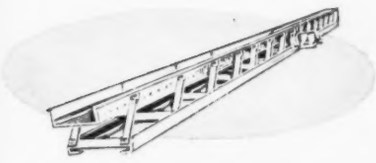
Other SYNTRON equipment of proven dependable quality



Test Sieve Shakers



Vibrating Screens



Mechanical Vibrating Conveyors

Roll Neck Seals

Lapping Machines

SYNTRON

SYNTRON COMPANY

699 Lexington Avenue • Homer City, Pa.

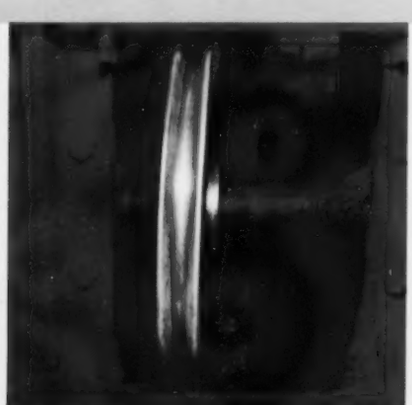
This TSP screw has produced over 8,506,151 tons of steel for Weirton Steel. It has been completely reconditioned and is now back in service at Weirton. Its service record has been so gratifying that Weirton uses TSP screws and nuts exclusively.

TSP screws and nuts

Almost nine million tons of steel have been produced with this "Tool Steel Process" screw and nut installed in 1955 at The Weirton Steel Co., division of National Steel Corporation, Weirton, West Virginia. This phenomenal performance record is characteristic of the results Weirton Steel has been getting with all TSP products in their plant. The result is great savings in maintenance, replacement and downtime costs. In addition to screws and nuts, TSP hardened products now in constant use throughout National Steel Corporation's many plants include cold rolling rolls, leveller rolls, cold processing rolls, all types of gears and pinions, drum sleeves, track wheels, sheave wheels, shafts, axles, and other miscellaneous hardened products. All TSP products have a file hard surface to the full depth of permissible wear for maximum life. The core, refined for toughness and ductility, gives maximum strength. Every TSP hardened product is positively guaran-

TSP hardened products have been used at Weirton Steel since 1928

TSP track wheels on slab yard crane.



TSP sheave on coke hoist shows no wear after 28 months service. Competitive sheaves lasted 8 months.

TSP pinch rolls on tin mill cleaning line.

MILLIONS IN TONS

only pennies in maintenance

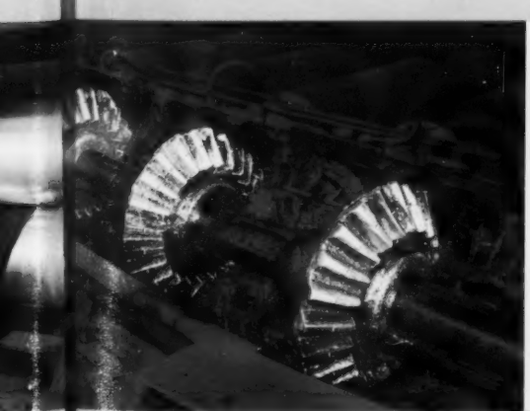
at WEIRTON STEEL

teed in writing to outlast, out-perform any competitive product in the same service. With the present highly competitive situation existing both here and abroad, the savings you can achieve by using long wearing TSP hardened products can help strengthen your position. Write for complete information on TSP products for the steel industry.

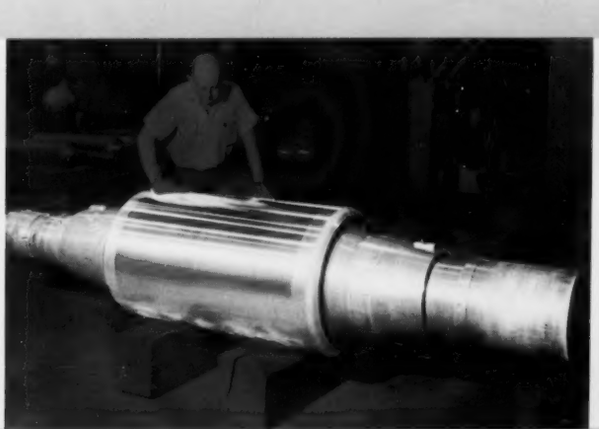
The standard of quality since 1909 for gears rolls • pinions • wheels and other hardened products.

THE
TOOL STEEL GEAR & PINION COMPANY

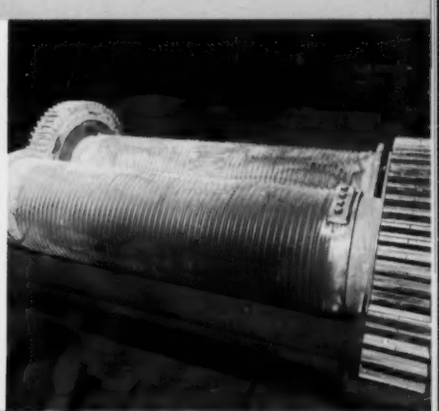
CINCINNATI / OHIO / USA



TSP bevel gears average 3 times life of competitive gears.



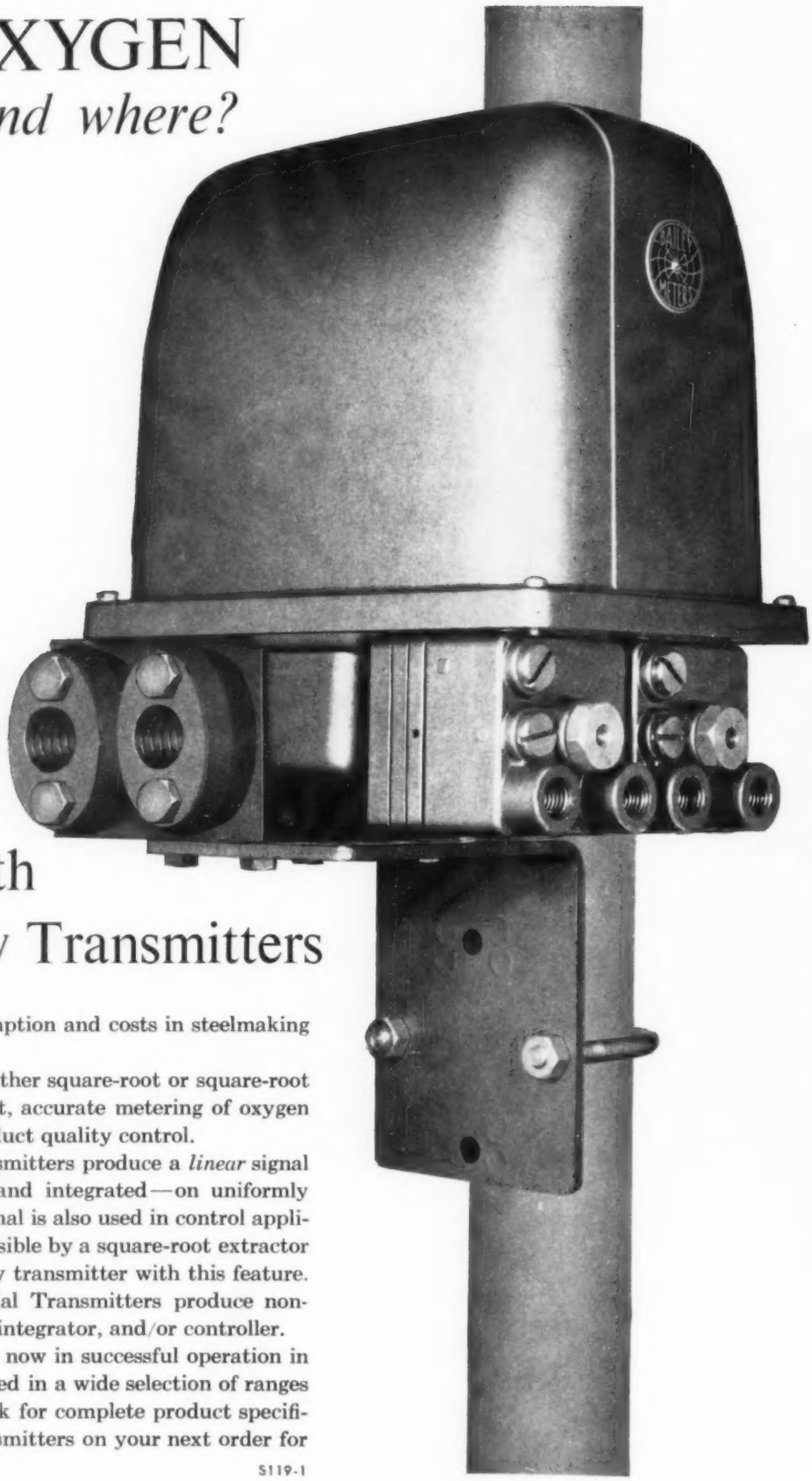
TSP 27½" x 45⅝" forged steel temper mill roll rehardened and ground and ready for further service.



TSP rope drum sleeves.

AD 1035-A Printed in U.S.A.

How much OXYGEN do you use..*and where?*



KNOW.. accurately..with Bailey O_2 Flow Transmitters

Why wonder about oxygen consumption and costs in steelmaking applications?

Bailey O_2 Flow Transmitters—either square-root or square-root extracting types—provide constant, accurate metering of oxygen use for better cost records and product quality control.

Bailey Force Balance Flow Transmitters produce a *linear* signal of flow which can be recorded—and integrated—on uniformly graduated scales or charts. This signal is also used in control applications. Linear signals are made possible by a square-root extractor integral with transmitter—the only transmitter with this feature.

Bailey Force Balance Differential Transmitters produce non-linear signals of flow to a recorder, integrator, and/or controller.

Bailey O_2 Flow Transmitters are now in successful operation in leading steel mills. They are supplied in a wide selection of ranges which may be readily adjusted. Ask for complete product specifications—specify Bailey Flow Transmitters on your next order for distribution meters.

S119-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

SIEMAG

PROGRESS
IN ROLLING MILL CONSTRUCTION

For high performance and economic service SIEMAG Rolling Mills

4-High Reversing Cold Mill for cold reducing and skinpassing steel strip

roll diameter	$26^{3}/_{8}$"/11"
body length	$21^{5}/_{8}$"
max. rolling speed	appr. 16,5 FPM

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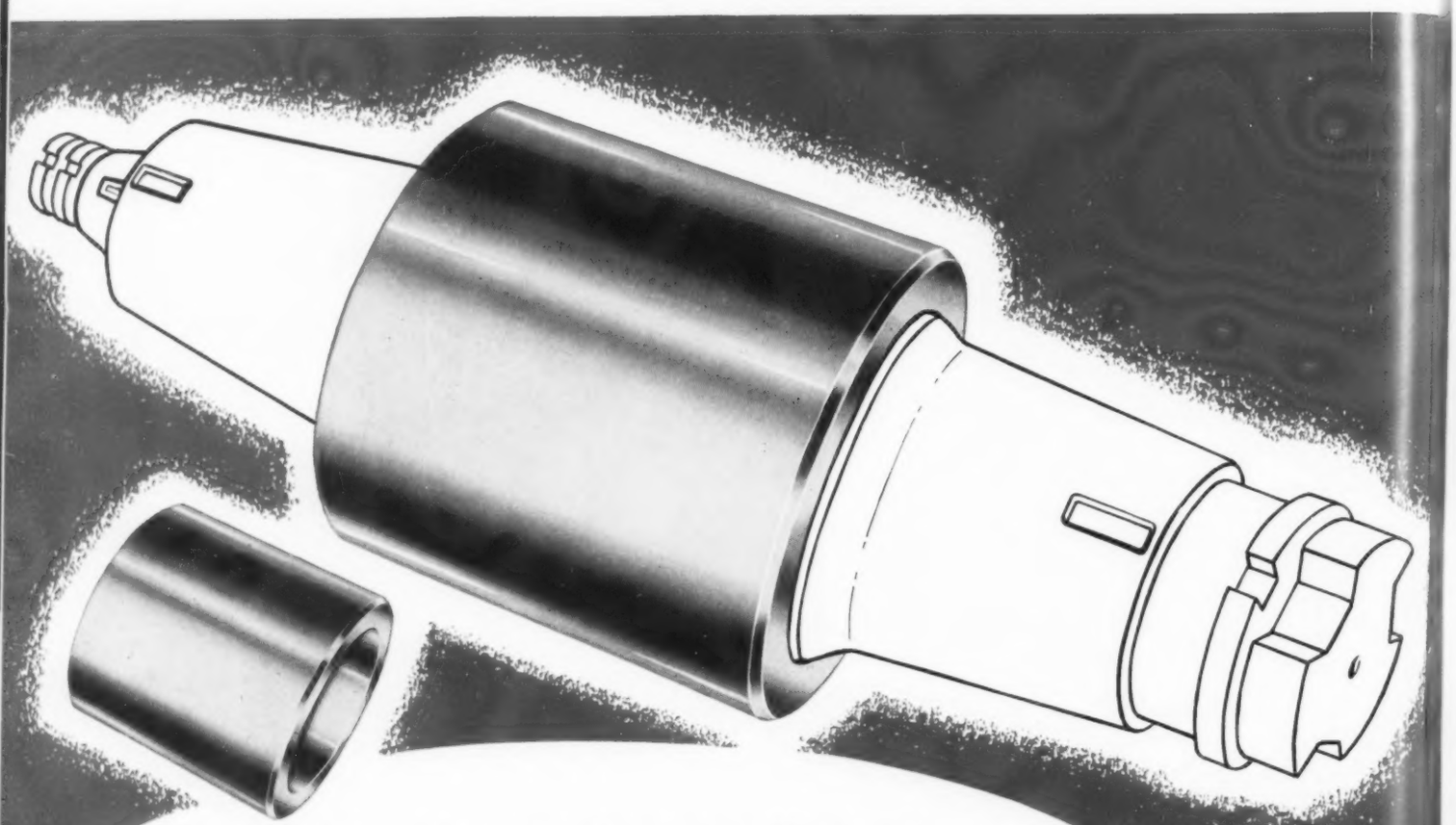
Telephone Hilchenbach, Kr. Siegen, 841

Düsseldorf Office, Berliner Allee 34-36, Telephone 10091

Ohio

FORGED SLEEVES

and Cast Steel or Forged Steel Arbors for Back-Up Rolls



A Complete Back-Up Roll Service

Ohio Steel—specialists in manufacturing all types of iron, steel and forged steel rolls—now offers the rolling mill industry *a superior forged steel sleeve for back-up rolls.*

Ohio back-up roll body sleeves are forged and hardened from *balanced alloy vacuum poured degassed steel.* These sleeves are accurately machined and applied to either new or used forged steel or cast steel arbors.

Yes, Ohio Steel offers a complete back-up roll service. Ask your Ohio roll sales engineer about this modern facility that can help increase rolling mill efficiency.

THE OHIO STEEL FOUNDRY COMPANY
LIMA, OHIO

OHIO IRON and STEEL ROLLS

Carbon Steel Rolls	Flintuff Rolls	Denso Iron Rolls
Ohioloy Rolls	Double-Pour Rolls	Nickel Grain Rolls
Ohioloy "K" Rolls	Chilled Iron Rolls	Special Iron Rolls
Nioloy Rolls	Forged Steel Rolls	

PLANTS AT LIMA AND SPRINGFIELD, OHIO. . *Virtually at the center of the Steel Industry*

OR-45

Industry News...

NEW ENAMELING STEEL PRODUCED BY BETHLEHEM

△ Eight large annealing furnaces for the production of vitreous enameling steel sheet have been installed at the Lackawanna, N. Y., plant of Bethlehem Steel Co., and production of the new material is under way.

The enameling steel, called Bethnamel, has superior enameling properties which permit a finish coat of enamel to be fired directly on it, thus enabling the enameler to eliminate the ground coat of enamel. Bethnamel can also be used advantageously for conventional two-coat enameling.

One popular use for the new steel is the gay-colored porcelain enameled panels employed in curtain wall construction of modern buildings. Other uses include sanitary equipment and a wide range of household appliances.

Bethlehem's Research Department developed the new enameling steel and has patented the enameled steel product as well as the method of making it.

The steel is produced by means of an open coil-annealing process. The process involves changing the chemistry of the steel by exposing the entire surface of a coil of sheet metal to special annealing gases. The main object is to reduce the carbon content, making the steel more ductile. The plant can reduce the carbon content to 0.001 per cent, as compared to 0.02 per cent carbon in traditional enameling stock.

One problem in achieving uniform decarburization of the coiled steel was in how to open the coils properly so as to expose the entire surface to the annealing gases. Bethlehem solved this problem by placing a specially-designed, kinked, wire spacer between the laps of a coil.

The open-wound coils are then placed in the annealing furnaces for hours of heat treatment which employs 1300 F as the best decarburizing temperature.

GARY ADDS CONTINUOUS ANNEALING LINE

This new high-speed continuous annealing line has been placed in full operation at United States Steel Corp.'s Gary, Ind., Sheet and Tin Mill. The new equipment will join present box annealing facilities at Gary to provide every type of tin-plate product required by can manufacturers. The line is designed to handle cold reduced strip in coil form ranging from 22 to 38 in. in width.

Much research was needed to determine the most satisfactory method of removing carbon without oxidizing the steel at the same time. The secret was to admit steam into the sealed furnace, along with a mixed gas consisting of 18 per cent hydrogen and 82 per cent nitrogen. Atoms of carbon were thus picked out of the steel to form carbon monoxide and carbon dioxide.

After a purging process, the decarburized steel is tight-wound and given a final skin pass rolling. It is then ready for enameling.

LADLE CRANE USES A-C REACTOR CRANE CONTROL

△ Stepless a-c reactor crane control built by General Electric Co. is now operating for the first time in Europe.

It controls smooth hoisting and pouring of 140-ton ladles of molten pig iron at the Ijmuiden (Netherlands) works of Breedband Steel Co. The huge ladle crane is located in the oxygen converter hall of the mill and is used to charge converters.

The Breedband installation is an innovation in two respects, according to General Electric. It is the first European use of a-c reactor crane control; it is also the first time such a system has been used on a steel mill hot metal ladle crane.

Built by GE's Industry Control Department, the equipment includes IC-7405 control for two 168-hp main hoist motors and IC-7406 control for the 134-hp auxiliary hoist motor. The main hoist motors normally operate in tandem; however, provision is made for emergency single-motor operation utiliz-

BUYING GAS GENERATORS ON PRICE ALONE IS A DANGEROUS PURCHASING PRACTICE

Experienced engineers and purchasing agents long ago discovered "you get exactly what you pay for" when buying gas generation equipment.

PERFORMANCE FAILURES due to substituting cheaper parts, in an effort to cut costs to get the order, have resulted in production delays that cost far more than was saved by purchasing the lowest priced generation equipment.

NO ASSURANCE OF RELIABILITY of the maker . . . except that he will produce a generator cheaper than anyone else . . . causes headaches a year or so later when parts are needed and he's already priced himself out of business.

LACK OF DEPENDABLE SERVICE can cost thousands of dollars in downtime. Gas Atmospheres builds the finest generators made today and, to protect our customers, we maintain the industry's largest service engineering staff.

Gas generation industry's most experienced service engineering staff. These Gas Atmospheres engineers are available for complete service work on any make of gas generation equipment. Call or write the address below.

Remember, Gas Atmospheres is the nation's foremost exclusive manufacturer of gas generation equipment. We do not build for price, but for quality. In the long run this pays off for everyone concerned. *Gas Atmospheres, Inc., 3855 West 150th Street, Cleveland 11, Ohio.*

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equipment for producing industrial gases

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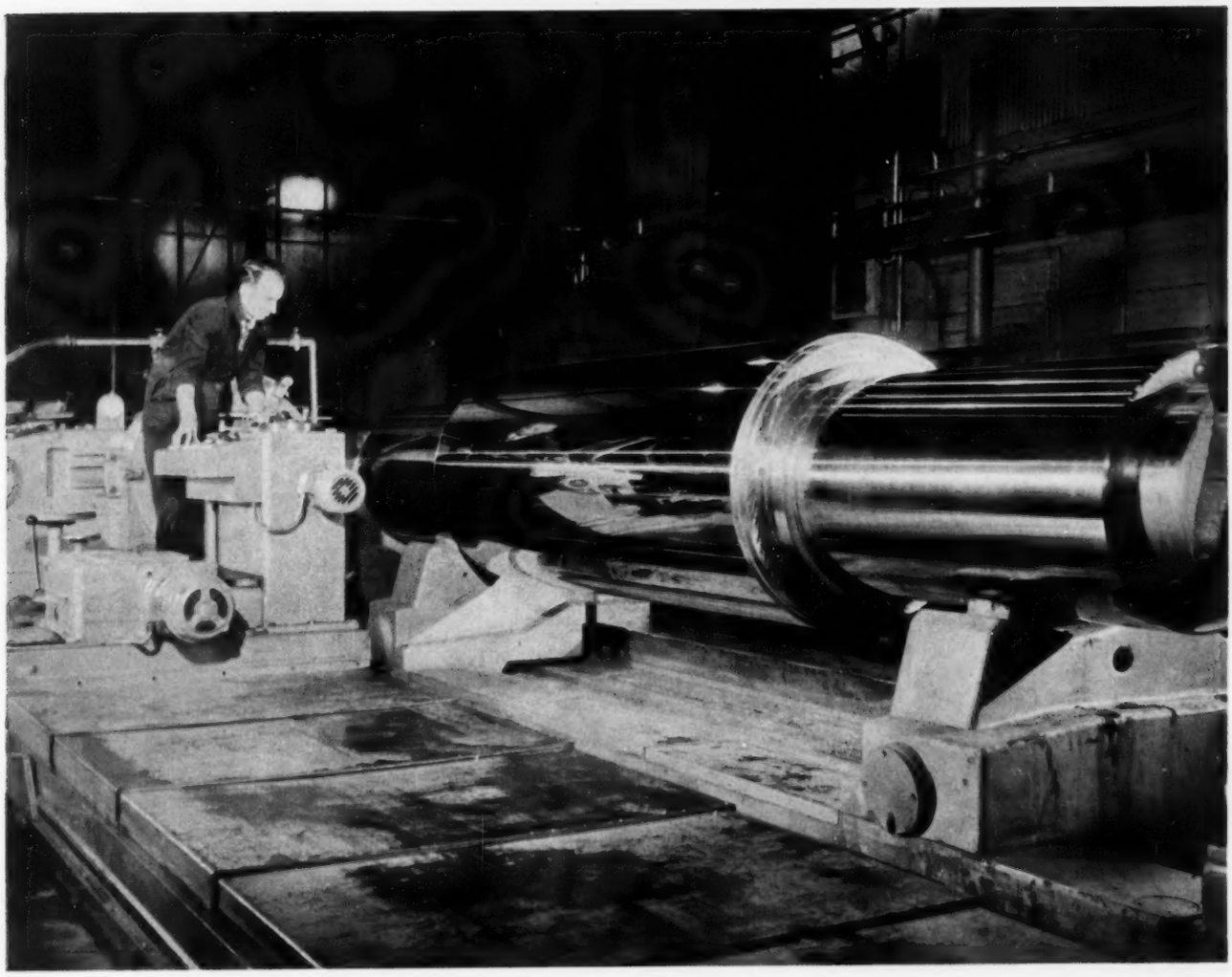
PACKAGED GAS SYSTEMS PACKAGED GAS SYSTEMS PACKAGED GAS SYSTEMS

The largest fully hardened Forged Steel Roll made in Europe



36″ Diameter
80″ long on Barrel
Weight 17½ tons
Supplied in
a super mirror finish

Firth Brown
ATLAS WORKS · SHEFFIELD · ENGLAND

ALLOY STEELMAKERS
FORGEMASTERS
STEEL FOUNDERS
HEAVY ENGINEERS

The mill will roll $1\frac{3}{64}$ in. to $1\frac{3}{64}$-in. diam rod from $3\frac{1}{8}$-in. sq billets. The maximum delivery speed when producing $1\frac{3}{64}$-in. rod will be 6900 fpm. The rod mill will have a monthly output of about 30,000 tons.

There will be four-strand rolling in the roughing train, two-strand in the intermediate and finishing trains. A special four-stand finishing train with horizontal and vertical stands (HV arrangement) will be provided for rolling exact round.

J&L ORDERS COLD MILL FOR THIN TIN PLATE

△ Contracts for a cold reducing mill for the production of double reduced tin plate have been awarded to the E. W. Bliss Co. by Jones & Laughlin Steel Corp.

The new mill is designed to process electrolytic tin plate into the new thin tin plate. Construction is scheduled to start this fall, and the unit is scheduled for operation in eight months. It will be part of a $12,000,000 capital expenditure program for thin tin-plate facilities.

J&L has been making its double reduced tin plate on existing equipment. The new mill will be a two-stand four-high mill. It will handle coils up to 42 in. in width and weighing as much as 45,000 lb.

The mill will be equipped with automatic gage control to provide greater product uniformity.

Completion of the cold reducing mill will permit J&L to substantially increase its production of the complete range of double reduced tin-plate products from 60 lb to 30 lb.

KOPPERS TO FURNISH CONTINUOUS CASTER

△ Koppers of Canada, Ltd., a subsidiary of Koppers Co., Inc., has received a contract from Premier Steel Mills, Ltd., Edmonton, Alberta, Canada, for a two-strand continuous billet casting machine which will provide steel for 75,000 tons of finished products per year.

Under the contract, Koppers will design and supply the machine and will supervise erection and start-up of the installation. The machine will have provision for expansion to four strands.

Premier Steel presently operates a two-furnace electric melting shop, casting billet-sized ingots for rolling in a merchant bar mill into reinforcing bars, merchant bars and low-alloy specialties.

Installation of the continuous casting machine is expected to improve material recovery and over-all product quality, as well as provide some economies of operation.

LINDE OXYGEN PLANT SUPPLYING LACKAWANNA

△ A new 310-ton per day on-site oxygen plant is now supplying Bethlehem Steel Co.'s Lackawanna, N. Y., facilities. The installation, built and operated by Linde Co., Division of Union Carbide Corp., replaces a 110-ton per day plant built by Linde in 1957.

Bulk of the oxygen supply will be used in Bethlehem's open hearth furnaces which have been converted to oxygen steelmaking techniques.

The plant will also provide oxygen for scarfing operations at Bethlehem's new slabbing mill.

HOW MUCH DO YOU PAY YOUR "WRECKING CREW"?
MORE THAN YOU CAN AFFORD...
if you waste man hours, destroy equipment and delay production by using sledge hammers to loosen stubborn materials in bins, bunkers, chutes and railroad car dumpers.
Put the punch of a Cleveland Vibrator on the job and end arching, bridging and sticking. Controlled hammer-like blows loosen your materials but not the supporting structures.
New rugged Type "KO" pneumatic vibrators have been engineered for steel plant applications where dust, water or inaccessibility shorten normal vibrator life. One piece construction eliminates bolts that might loosen or break. The hardened, ground, and hard-chrome plated piston is the only moving part and its Micro-finish bore can be automatically or permanently lubricated to end routine oiling. Simplicity of design and low air consumption make the Type "KO" less in purchase price, less in operating cost, less in maintenance expense than previous models.
Find out how Cleveland Vibrators can move materials from High Line Stock Bins, Sintering Plant Ore Bins, Power Plant Coal Bunkers and Bins, Coke Plant Coal Bins and Chutes, and Rotary Railroad Car Dumpers. A description of your problem will bring a free estimate with no obligation.
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Bin Stuck Lately?
AIR OR ELECTRIC
SILENT OR STANDARD
PORTABLE OR PERMANENT
THE CLEVELAND VIBRATOR CO.
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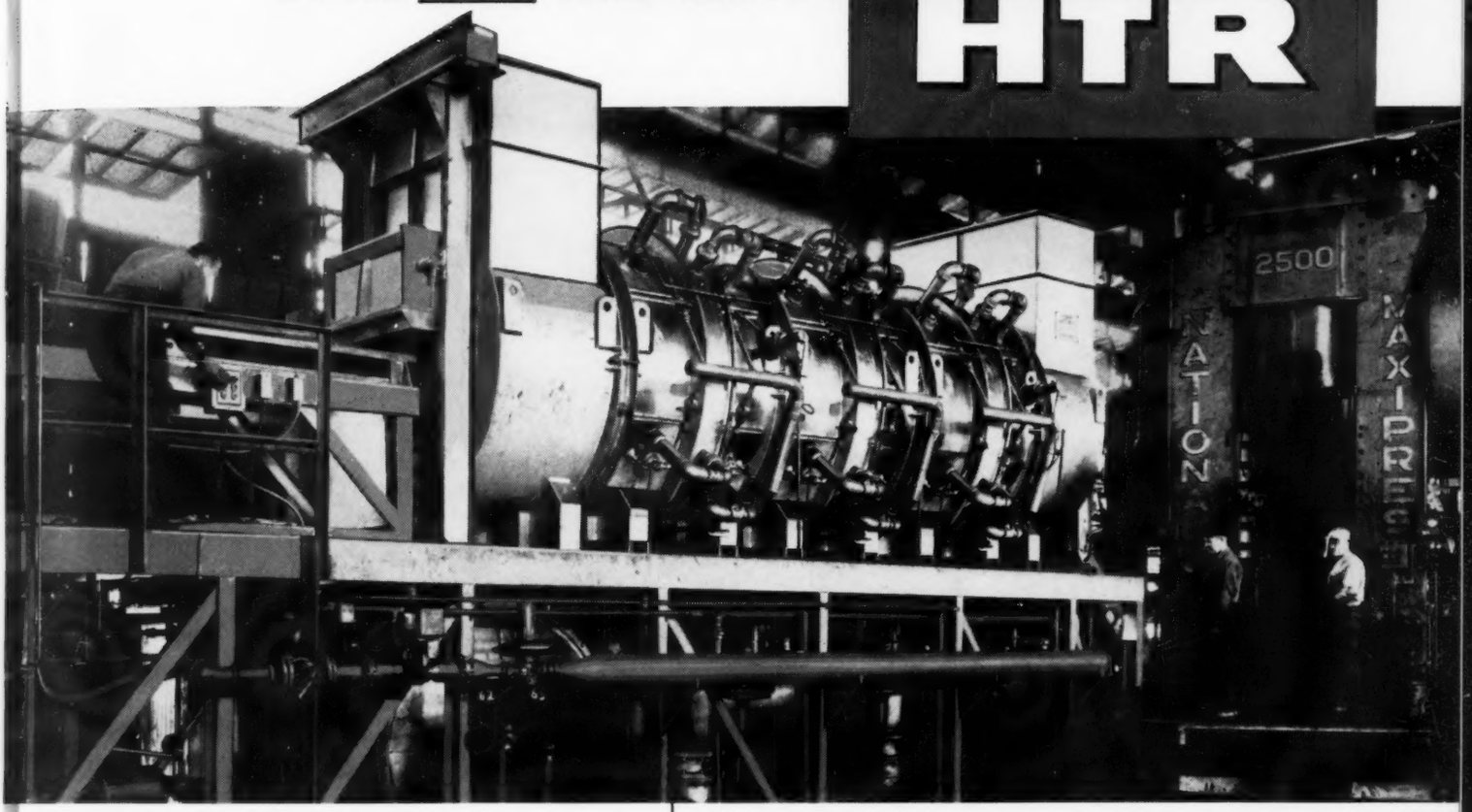
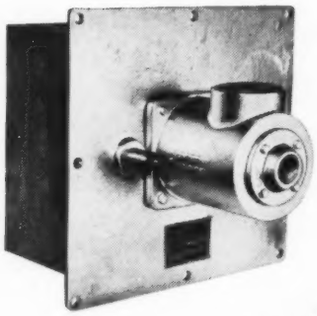
HIGH-SPEED HEATING

at its BEST with the . . .

BLOOM HTR

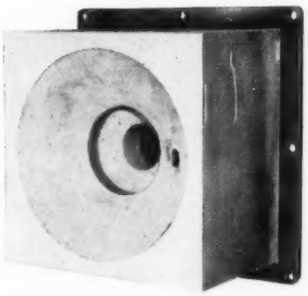


Courtesy of Gas Machinery Co.



No metallic parts exposed to high temperature.

Contoured port block gives high temperature radiating surface with no forward flame velocity.



Bloom HTR Burners were selected by the furnace builder to fire this high speed pusher type forge furnace. High heat release without flame impingement on the product and adaptability to furnace shape made the HTR Burner ideal for the job. Here are the results:

OPERATION

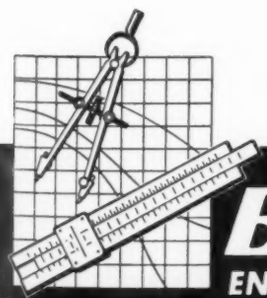
Material	4" cubes
Production rate	8000 lbs. per hour
Heating time	8 minutes—2 minutes per inch
Furnace temperature	2650°F
Scale condition	so light that no special scale removal equipment is needed.

MAINTENANCE

No furnace repairs } in first year
No burner or port block maintenance } of operation.

Other successful HTR Burner applications include:

Tube Upsetting
Continuous Strip Pre-Heating, Annealing, Coating, and Drying
Batch type Forging
Aluminum Chip Melting
Glass Melting



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue — Pittsburgh 33, Pa.

ENGINEERING EXPERIENCE EQUIPMENT

POLLOCK TO FURNISH FOUR TRANSFER CARS

△ The William B. Pollock Co. has been awarded a contract to build four 250-ton mixer type hot metal transfer cars, the largest ever built in the United States, for Sharon Steel Corp.'s plant in Farrell, Pa.

These 16-wheel cars will transfer molten iron from the blast furnaces to the new Stora Kaldo furnaces now in construction at Farrell.

The Pollock all-welded hot metal transfer car will carry close to 300 tons of hot metal on a worn lining.

RELOCATED STRIP MILL BEGINS FULL OPERATION

△ Installation of a million dollar specialty strip mill operation, capable of producing more than 30,000 tons a year is nearing completion at the Precision Strip Mill Division of Solar Steel Corp. at River Rouge, Mich.

Production of magnetically gaged, close tolerance steel strip in the expanded plant will begin about Oct. 1, according to Harry D. Curtis, Precision Strip Mill Division manager.

The installation has been a two-year project with some of the equipment already in operation. The mills formerly were operated as a subsidiary of Solar Steel in Bridgeport, Conn., before the transfer.

The completion marks the latest step in a more than $2,000,000 manufacturing expansion by Solar Steel. The firm has just completed installing an automated welded tube mill in its Shapeweld Division plant in Union, N. J.

Equipment added to the Detroit plant includes two tandem roughing mills, a 20-ton bell-type atmospherically-controlled bright-anneal furnace and six cluster-type finishing mills capable of producing plating quality strip finishes.

Tolerances as close as plus/minus 0.00025 in. are maintained by continuous contact magnetic gages.

The mills will produce widths up to 13 in. and thicknesses from 0.008 in. to 0.1875 in. in steels up to 0.60 carbon.

New auxiliary equipment includes a special edge finishing mill and a shear line. The edging unit can produce edges that are perfectly square, round or tapered on one or both edges.

RECEIVE LADLE ORDER FROM WEIRTON STEEL

△ Pennsylvania Engineering Corp. has received a contract for 28 bottom pour ladles from Weirton Steel Co., Division of National Steel Corp.

The contract covers 16 ladles of 280-ton capacity and 12 of 230-ton capacity. Design of the twelve smaller ladles is such that they can be modified to accommodate 280 tons after they have been in service, at minimum cost.

REBUILT BLAST FURNACE PLACED IN OPERATION

△ A blast furnace at the Cleveland works of Jones & Laughlin Steel Corp. has been put back into production following a face-lifting project which increased its rated capacity by about 10 per cent.

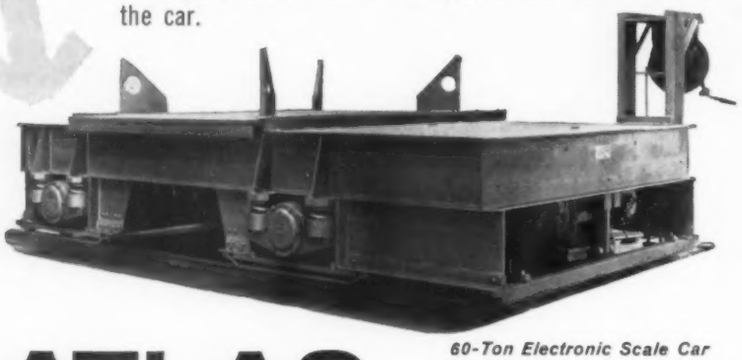
Tape Recording

Chart Recording

Atlas Builds Electronic Scales for -

Blast furnace scale cars, Coke weighing, Scrap bucket charging

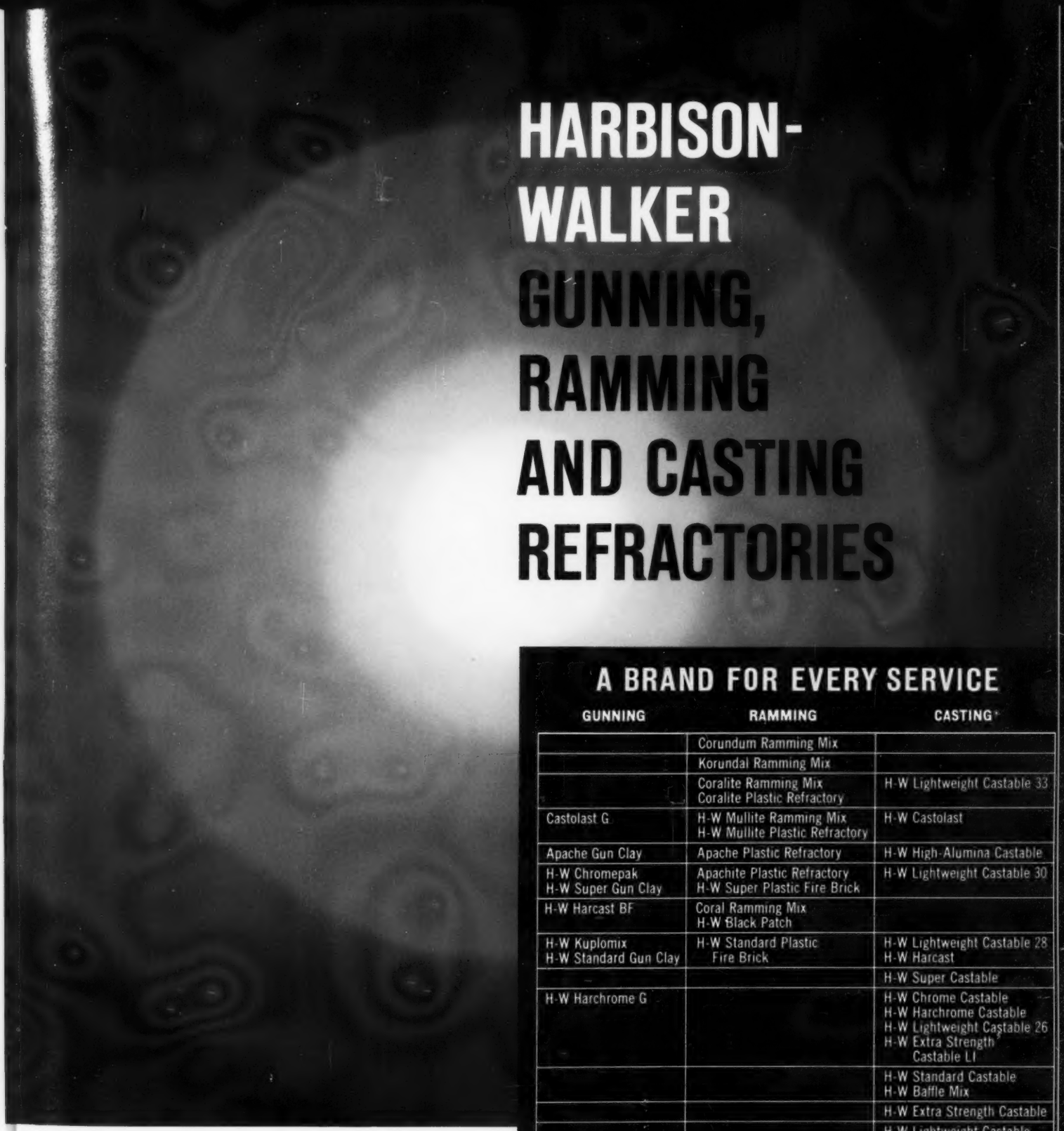
This 60-ton scale car handles scrap buckets from the scrap yard to electric furnaces. For safety, the operator controls the car movement from a remote location. The electronic scale dial is mounted where the crane operator can watch it while loading the car.



60-Ton Electronic Scale Car

ATLAS CAR & MFG. CO.

1100 IVANHOE ROAD / CLEVELAND 10, OHIO



HARBISON-WALKER GUNNING, RAMMING AND CASTING REFRACTORIES

A BRAND FOR EVERY SERVICE

GUNNING	RAMMING	CASTING*
	Corundum Ramming Mix	
	Korundal Ramming Mix	
	Coralite Ramming Mix Coralite Plastic Refractory	H-W Lightweight Castable 33
Castolast G	H-W Mullite Ramming Mix H-W Mullite Plastic Refractory	H-W Castolast
Apache Gun Clay	Apache Plastic Refractory	H-W High-Alumina Castable
H-W Chromepak H-W Super Gun Clay	Apachite Plastic Refractory H-W Super Plastic Fire Brick	H-W Lightweight Castable 30
H-W Harcast BF	Coral Ramming Mix H-W Black Patch	
H-W Kuplomix H-W Standard Gun Clay	H-W Standard Plastic Fire Brick	H-W Lightweight Castable 28 H-W Harcast
		H-W Super Castable
H-W Harchrome G		H-W Chrome Castable H-W Harchrome Castable H-W Lightweight Castable 26 H-W Extra Strength Castable LI
		H-W Standard Castable H-W Baffle Mix
		H-W Extra Strength Castable
		H-W Lightweight Castable Extra Strength
		H-W Low-Iron Lightweight Castable 22 H-W Lightweight Castable 22
		H-W Lightweight Castable 20
		H-W Lightweight Castable 10 H-W RC Castable

*These products may also be gunned.

A complete series of gunning, ramming and casting refractories is available from Harbison-Walker to meet every furnace operating condition and temperature requirement. Harbison-Walker engineers will help you select the proper brands to assure best balanced service life. Write us for complete details.

TYPICAL FURNACE APPLICATIONS: ARCHES · ASH PITS · BOILER SETTINGS · BREECHINGS · BURNER BLOCKS · BAFFLES · CATALYTIC REACTORS · DOOR LININGS · DUCTS AND PIPING · ELECTRIC FURNACE ROOFS · HEARTHS · INSULATION · KILNS AND CARS · LADLE LININGS · ROTARY KILN CHAIN SECTIONS, HOODS, COOLERS AND DUST CHAMBERS · SOAKING PIT COVERS · INDUCTION FURNACE LININGS

HARBISON-WALKER REFRACTORIES CO. AND SUBSIDIARIES *World's Most Complete Refractories Service*

GENERAL OFFICES: PITTSBURGH 22, PENNA.

HARBISON-WALKER MONOLITHIC REFRACTORIES

Now packaged for easy handling and time saving on job site

Newly-designed square-end bags, zip-open cartons and sturdy steel drums provide users of Harbison-Walker's monolithic refractories with easy handling, better palletizing and efficient storage advantages. A distinctive color for each brand speeds product identification on the job site.

The bags for packaging castables are made of sturdy, multi-wall, moisture-proof material. Brand names and mixing directions are clearly printed on each bag. The easy-to-handle zip-open cartons contain plastic refractory slabs wrapped in polyethylene moisture-proof material, insuring good shelf life. The results—besides easy and efficient handling—substantial savings of time and labor in installation.

HARBISON-WALKER REFRACTORIES CO.
AND SUBSIDIARIES *World's Most Complete Refractories Service*
GENERAL OFFICES: PITTSBURGH 22, PENNA.

HW 61-15

The blast furnace, one of two at the works, was taken "off the line" earlier this year for repairs and a rebuild project resulting in a larger hearth diameter and working volume.

The furnace, which has produced more than 3,600,000 tons of iron since it went into operation in 1952, was relined with carbon hearth sidewalls as a replacement for the former sidewalls of ceramic materials. The thinner sidewalls have increased the hearth diameter from 25 ft-9 in. to 26 ft-6 in. The new lining material, coupled with new stack cooling plates, is expected to increase lining life.

The working volume of the furnace has been increased from 38,870 cu ft to 41,240 cu ft, making it one of the largest of the J&L blast furnaces.

The rebuild project also has increased the plant's program for smoke control through the installation of high top pressure bleeders on the furnace. This equipment increases the efficiency of the furnace gas washers thereby minimizing the emission of gas and dust into the atmosphere.

ARGENTINE FIRM ORDERS ROTARY STRAIGHTENER

△ A Model A-1 Mackintosh-Hemphill rotary pipe straightener, the fastest straightener ever purchased for use outside North America, has been ordered complete with entry and delivery tables by Acindar, S.A., a major steel producing firm located in Buenos Aires, Argentina.

This equipment will weigh close to 90,000 lb. It will be used to straighten standard, line and extra-heavy pipe in sizes from $\frac{3}{8}$ in. to 4 in. at speeds up to 900 fpm. The straightener will employ six driven cross rolls, angled so that the pipe will be rotated and flexed during passage through the machine, assuring excellent straightness and roundness. Rolls for this machine, as well as other types of steel mill rolls, can be supplied locally by Acindar's associate firm Acinfer, S.A. No fixed guides will be used, eliminating scratching or marking on the pipe surface.

The pipe straightener is scheduled to be delivered by the end of the year.

NEW CONTINUOUS CASTER PLACED IN OPERATION

△ A vertical-type continuous casting plant for steel, built by Schloemann Aktiengesellschaft, Düsseldorf, in association with Concast Aktiengesellschaft, Zürich, was recently taken into commission by the Dillinger Steelworks.

The plant is to be employed for the casting of slabs to serve as starting material for the manufacture of plate and strip. At the present time 40 in. x 8-in. slabs are being produced.

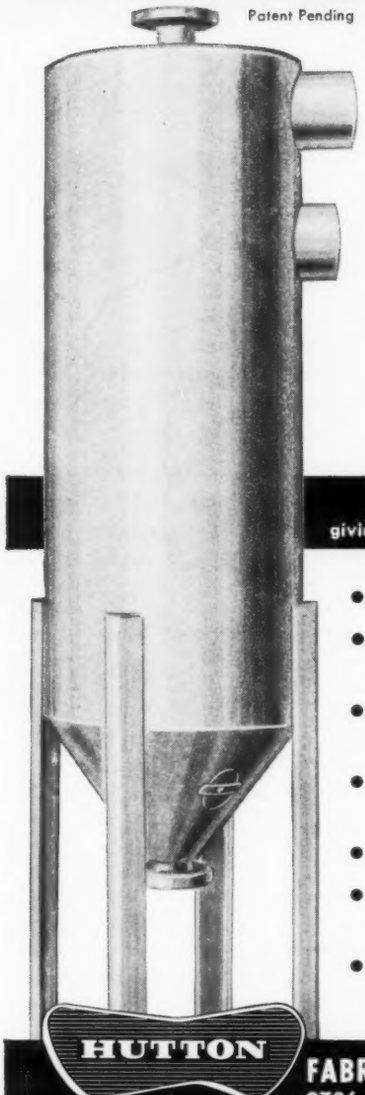
It is proposed soon to take up the production of 60 in. x 8-in. slabs.

NO. 2 BLAST FURNACE BLOWN IN AT WEIRTON

△ All four blast furnaces at Weirton Steel Co., division of National Steel Corp., are now in operation following the relighting of No. 2 furnace after a two-month shutdown for relining.

A New Revolutionary Method of

KEEPING WATER LINES CLEAN!



Patent Pending

Stops Plugging of Spray Nozzles Prevents Damage to Water-cooled equipment

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giving useful information on Hutton Water Line Purifiers

- Removes fine sludge, mud, silt, sand
- Separates out material that traveling screens cannot
- Designed by world's leading entrainment specialists
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Open Hearth and Electric Furnace Doors and Frames • Oxygen Lances

Special Steel Mill Fabrications • Water Line Purifiers

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

How to get the most from cogging hammer dies

For many years, we have supplied cast steel dies that are used for cogging ingots into billets and blooms. During this time, we've been aware of the variation in the service life of identical dies used in different plants under apparently similar conditions. As a result, we have tried to find out the cause.

HERE IS WHAT WE HAVE FOUND

Tricks of fitting spell the difference: Each blow of a drop hammer generates tremendous pressure at the moment of impact. For a 5-ton hammer, this pressure could approximate 10,000 tons. Hence, it is vitally important that the faces of the top and bottom dies be exactly parallel. Equally important is close fit of the dies in the top and bottom die holders.

The hot forming department at Universal-Cyclops' Titusville, Pa., plant gets the longest cogging hammer die life that we know of. Thus, a close look at Titusville's practice should be helpful.

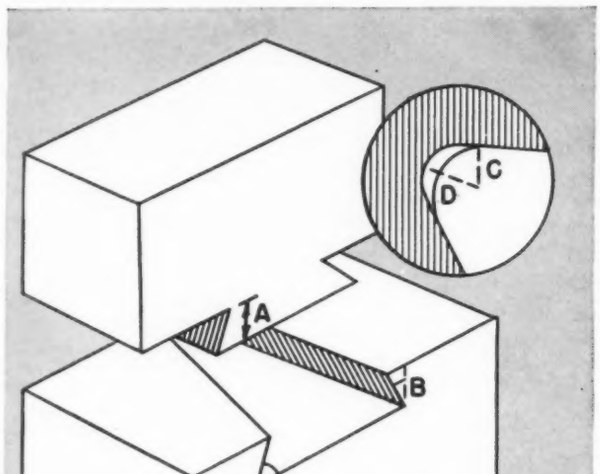
You can't argue with success: Let us take a specific case — the adjustment and fit of the bottom die in the sow block of one of Universal-Cyclops' 5-ton hammers (all remarks on tolerances apply equally to the fit of the top die in its holder).

Starting with new dies, the face of the shank key is machined to zero, and the wings are machined as close to the 3" setback as possible. Actual tolerance limits here are 3" min. and 3.004" max., making the die key face at most .004" high.

After extended use, the 16,000-pound sow block may shift slightly, causing the dies to go out of parallel as much as 5/8". Before removal for redressing, parallelism of the dies is checked, and if necessary, the face of the bottom die is machined to bring it into parallel with the top die.

Avoid weak points: Close seating tolerances are not the only prerequisites for maximum die life. Areas of potential structural weakness must be carefully avoided. For example, the fillet radius at the corner where the die shank key joins the die wing and the mating radius in the die holder should leave a space enough to sight between the die and holder. Universal-Cyclops uses 3/8" and 1/2" as these complimentary radii.

The angle of the shank key from the vertical is purposely kept to 7° for best performance. The greater the angle, the more the shearing effect as the relatively light die rebounds from the heavy anvil after each blow, tending to tear the shank.

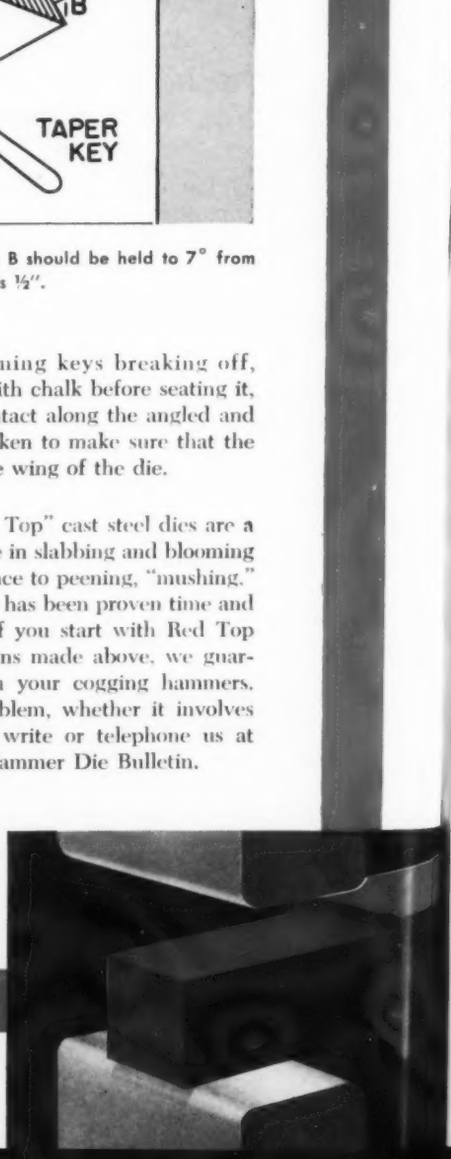


Dimension A is 3.000" + .004". Angle B should be held to 7° from the vertical. Radius C is 3/8"; Radius D is 1/2".

To guard against shank retaining keys breaking off, Universal-Cyclops blues the key with chalk before seating it, and then checks it for uniform contact along the angled and tapered faces. Moreover, care is taken to make sure that the key isn't so high that it touches the wing of the die.

Choice of dies: Mack-Hemp "Red Top" cast steel dies are a development of our long experience in slabbing and blooming mill rolls. Their remarkable resistance to peening, "mushing," spalling and other varieties of wear has been proven time and again in open die forging work. If you start with Red Top dies and then follow the suggestions made above, we guarantee improved performance from your cogging hammers.

For help with your specific problem, whether it involves forging dies or mill rolls, simply write or telephone us at HE 1-3000, or send for our free Hammer Die Bulletin.



MACKINTOSH-HEMPHILL

You get more tonnage from "the rolls with the Striped Red Wabblers"

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery

The No. 2 furnace had produced 3,266,294 tons of pig iron between the time it was last relined in 1954 and the halting of operations on June 17 of this year at which time the current relining began.

In the relining project, the crucible walls were lined with carbon up to the centerline of the slag notch, new copper cooling plates were installed, an existing gas washer was modified, and an orifice-type gas cleaner was added.

Built in 1926 with a 21 ft-6 in. hearth, the furnace was enlarged in 1937 to 23 ft-6 in., and in 1947 was enlarged to its present hearth size of 25 ft-6 in. It is 92 ft in height and has a capacity of 1775 tons of pig iron per day.

The company's No. 1 and No. 3 blast furnaces have the same hearth size as No. 2, while the No. 4 furnace, which was relit on April 17 of this year following relining, has a 27-ft hearth.

CONTRACT AWARDED FOR STRATEGIC-UDY PLANT

△ Koppers International, C.A., a subsidiary of Koppers Co., Inc., has received a contract from Acoje Mining Company (Manila, The Philippines) for a ferrochrome plant to be built near Iligan City on the island of Mindanao in The Philippines.

The plant will utilize the Strategic-Udy direct reduction process, under license from Strategic Patents, Ltd., a wholly-owned subsidiary of Strategic Materials Corp.

Included in the Koppers contract are preparation of specifications and basic engineering designs, coordination of other engineering work to be done by Acoje in Manila, and general technical assistance in construction and start-up of the plant. Key employees of Acoje will be trained by Strategic and Koppers personnel at the commercial ferrochrome plant of Strategic at Niagara Falls, Ontario. Production of ferrochrome should commence approximately 15 months after construction of the plant begins.

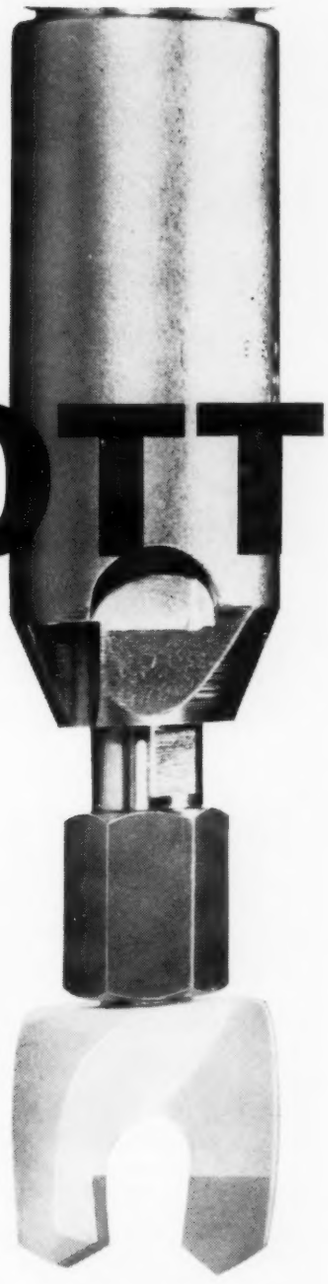
HONEYWELL SIMULATOR RUNS OTHER PROGRAMS

△ Minneapolis-Honeywell Regulator Co.'s Electronic Data Processing division has introduced simula-

to clean badly clogged air preheater tubes

ELLIOTT

heavy duty tube cleaner



Shown above is the powerful Lagonda heavy-duty air motor with carbide-tipped cutter bit. Attached to a flexible air hose, this unit can operate in any position where headroom is limited. The carbide tip will clean even the most badly clogged tubes, quickly and effectively.

Where headroom permits, the heavy-duty suspended-type motor shown at the right can be used to drive a cutting bit attached to a hollow steel shaft, through which flushing and cooling water is fed. This extremely powerful unit can be used either vertically or horizontally.

Full information and prices may be obtained from any Elliott District Sales Office, or by writing Elliott Company, Lagonda Plant, Springfield, Ohio.

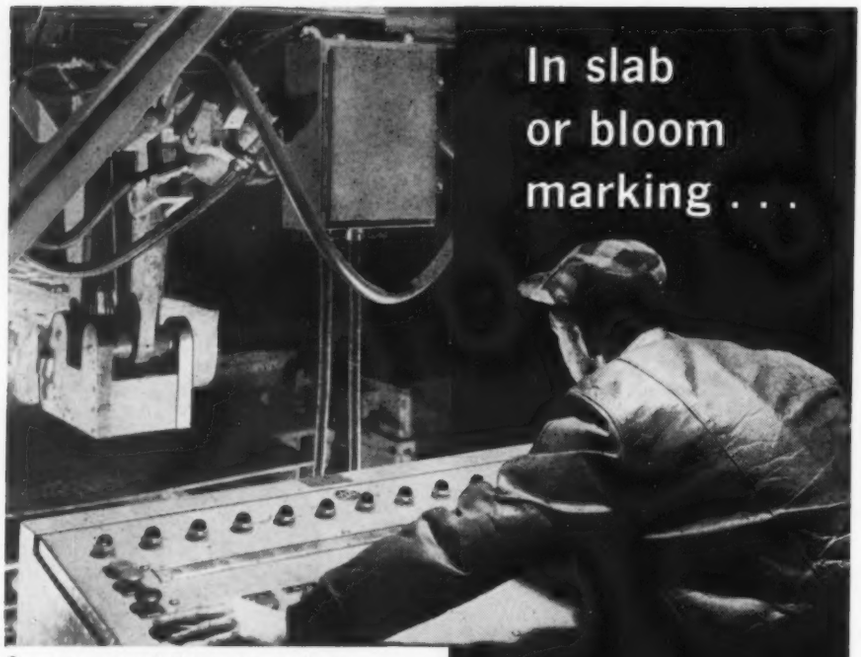
Y 1-1

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

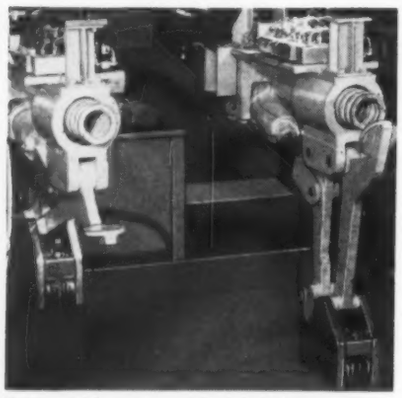
PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
DEAERATING HEATERS • EJECTORS • CONDENSERS • STRAINERS • TUBE CLEANERS



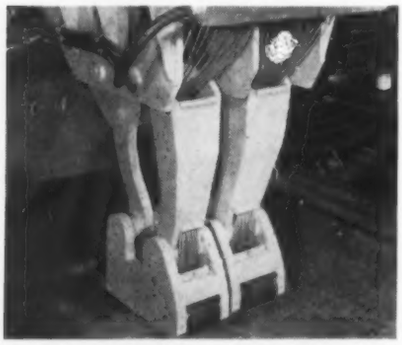
Operator presses button to actuate stamping cycle or change characters—installed at a transfer table.

CUNNINGHAM
HAS THE
EXPERIENCE



Twin units for automatic consecutive numbering of 2½" bar billets—for installation along edge of cooling bed.

17 UNITS IN SERVICE
. . . MORE ON ORDER



Double-headed Slab Marker with 18 stamping wheels, photographed during testing—for installation over a roller line.

Under constant development for more than 13 years, Mecco Safety Slab Markers are the industry's most advanced–*the most thoroughly service-proved,* by a margin of hundreds of thousands of tons.

We'll gladly consult with you on any phase of steel industry marking. *May we send technical bulletins on Slab Markers?*

Mecco SAFETY MARKING TOOLS

M. E. CUNNINGHAM CO.
1041 CHATEAU STREET
PITTSBURGH 33, PENNA.

tors that make it possible to runoperating programs written for IBM 650 and Univac computers directly on Honeywell 800 systems without modification of the non-Honeywell programs.

The simulators, described as machine programs packaged on magnetic tape, have been prepared primarily to enable Honeywell customers to utilize non-Honeywell program libraries while converting to new programs using the Honeywell 800, said Walter W. Finke, president of the EDP division.

He explained that the simulators are available in several versions. They include a Card 650 Simulator and a Tape 650 Simulator, as well as simulators for Univac I, Univac II and a special Univac system.

He said that all computer functions can be simulated, including floating point arithmetic, tape operations and index registers. Univac and 650 card programs can be run without change and tape programs only require conversion of present tapes to Honeywell 800 tapes.

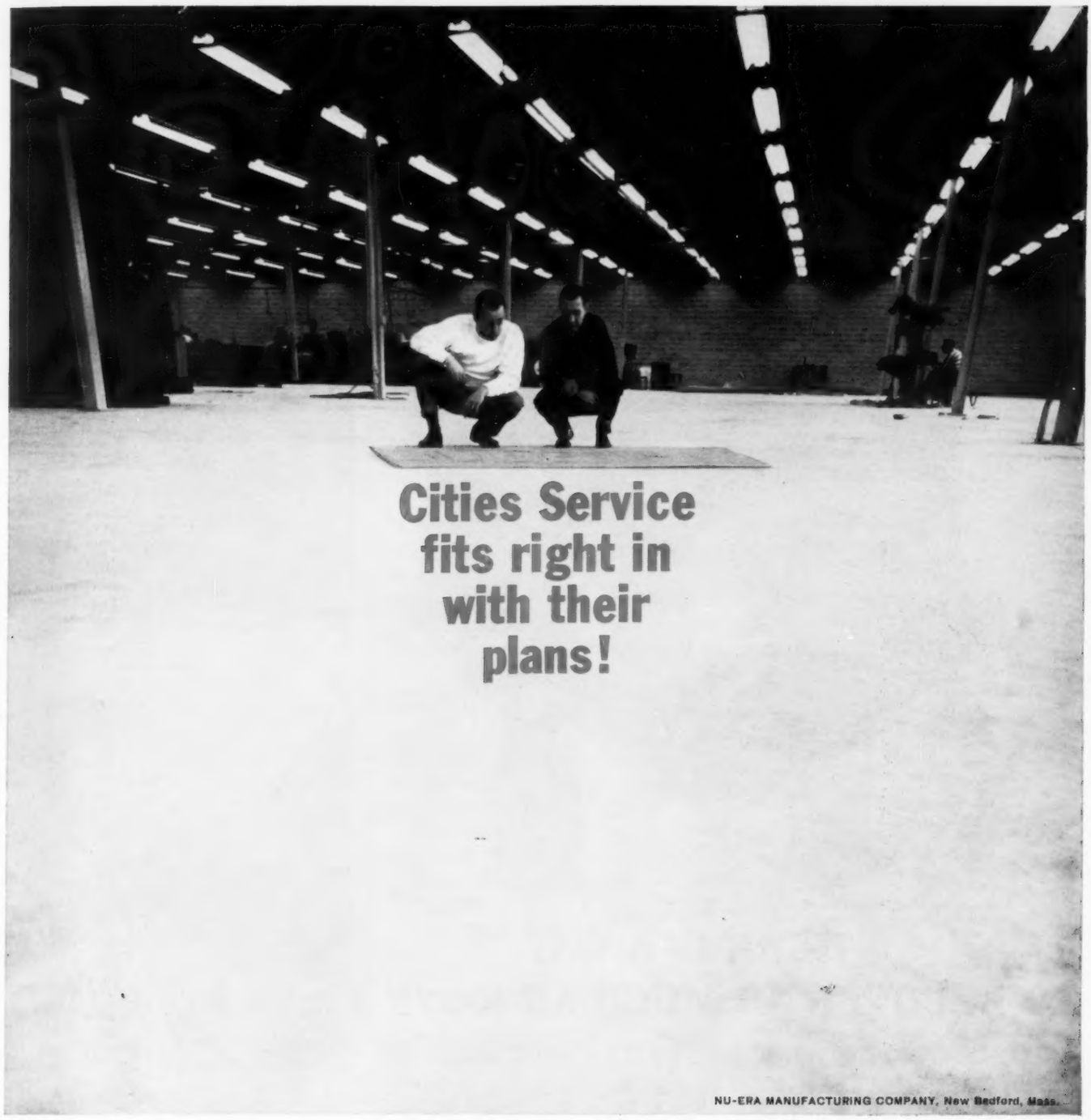
FRENCH FIRM PLANS GLASS EXTRUSION UNIT

△ The first installation in the world for the glass extrusion of long-length carbon steel tubes will be set up by a leading French tube producer, Lorraine-Escaut, in its Anzin plant in the north of France.

The plant will use the Ugine-Sejournet process for glass-lubrified steel extrusion under license from CEFILAC, a subsidiary of France's electro-metallurgical firm, Ugine.

This French process, invented in 1941 and developed soon after the war has been applied industrially since 1948 and has already been licensed to 34 companies in nine countries, including fifteen in the United States. Up to now, it has been used mainly for the production of high-quality alloy and stainless steel tubing and shapes. Lorraine-Escaut will be the first to use this process for carbon steel tube production.

The main feature of the Ugine-Sejournet extrusion process is that it eliminates friction between the steel billet and the tools by the use of glass which operates as a lubricant at high temperatures and insulator. Weight of the billets fed



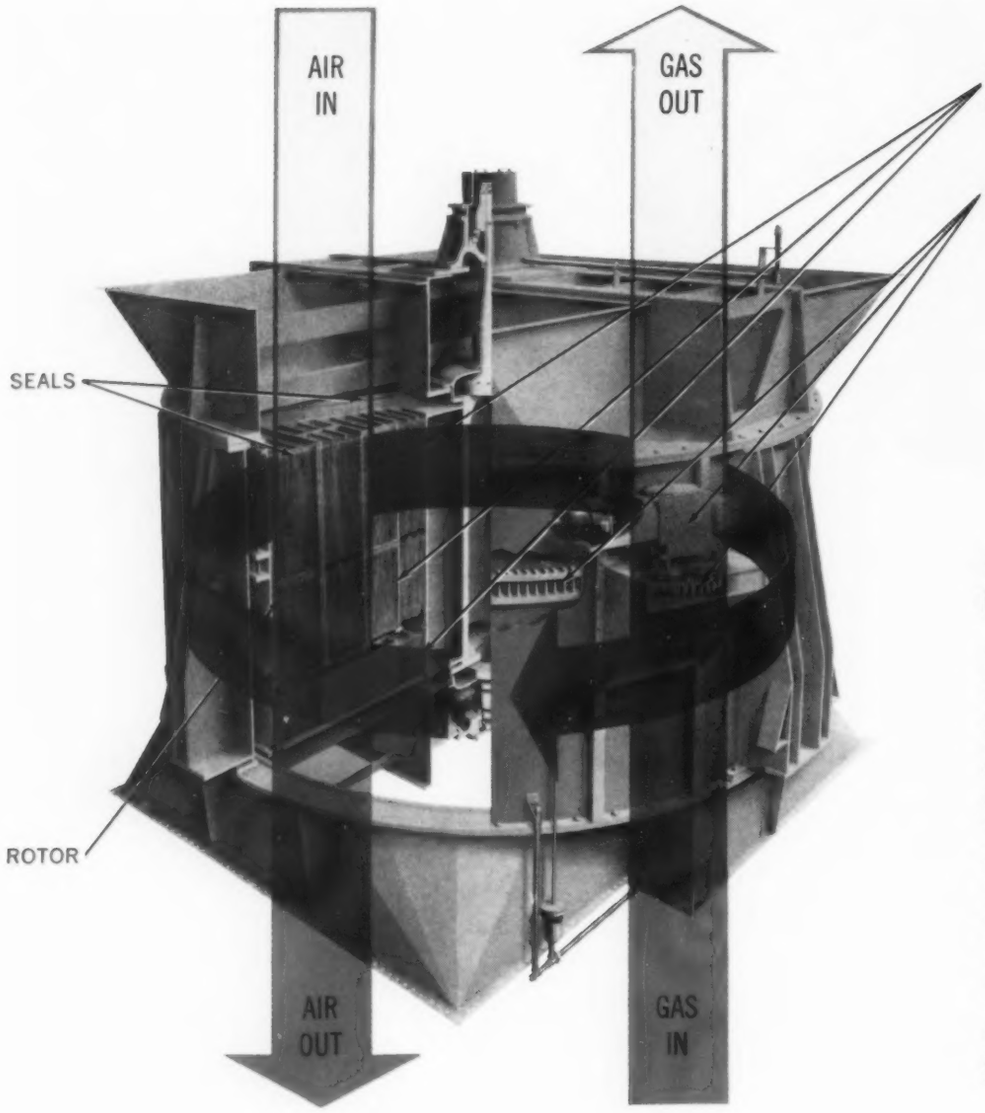
Cities Service fits right in with their plans!

NU-ERA MANUFACTURING COMPANY, New Bedford, Mass.

There's a bright future ahead for Nu-Era, manufacturer of replacement gears. The firm recently built this huge plant to handle increased orders... and Cities Service definitely fits in with their plans. Says General Manager Bill Rebone, "At first, all cutting oil brands seemed to be the same. However, we soon realized that Cities Service oils were giving us superior performance in every respect. Most of our gears are made of #5135 steel, a real tough customer to work with. Yet, we find we're getting long tool life, extra clean cuts with Cities Service Chillo 30 Cutting Oil." Nu-Era now relies, exclusively, on Cities Service for their metal machining fluids. Find out how Cities Service can fit in with your plans. Simply contact your nearest Cities Service office or write: Cities Service Oil Company, 60 Wall Street, N.Y. 5, N.Y.

CITIES SERVICE

Out Front in Quality... Out Front in Service, too!



Cutaway shows how Ljungstrom® works

1. Ljungstrom is enclosed in gas tight housing with seals to separate flue gas and air.

2. Flue gas and combustion air pass axially through Ljungstrom in continous counter flow.

3. Rotor revolves slowly through both flue gas and air stream, continuously absorbing heat from flue gas and releasing it to incoming air.

4. Heating surface consists of many formed metal sheets packed in rotor. Elements are packed in baskets for easy inspection, removal or replacement.

5. Units can be arranged for vertical gas flow (as shown) or for horizontal flow.

HERE IS A WAY TO RECOVER AS MUCH AS 1000°F FROM FLUE GAS

. . . and cut your fuel costs 1% for each 35° - 40°F recovered!

More complete combustion . . . higher furnace temperatures . . . increased furnace capacity . . . improved product – these are established advantages of preheating combustion air. And the Ljungstrom® Air Preheater, *on the basis of fuel savings alone,* deserves careful investigation. For it is *the* most efficient metallic heat exchanger ever developed. It can recover as much as 1000°F from flue gas, with savings in fuel costs of 1% for each 35° - 40°F recovered.

High efficiency in extremely small space

The Ljungstrom rotor revolves continuously through the flue gas and incoming air . . . absorbs heat and releases it from *the same surface.* Since heat does not have to pass *through* the heat exchange surface, the Ljungstrom is remarkably efficient and compact. A unit measuring 5′ x 7′ x 8′, using 2000°F flue gas diluted to 1500°F, can handle a furnace exhausting 30,000,000 Btu/hr and raise incoming air from 70°F to 1400°F.

Applications in the steel industry

Ljungstroms can perform efficiently in many steel-making applications: reheat furnaces, soaking pits, slab, billet and skelp furnaces. Used in series with checkers they can provide far higher and more uniform preheating than any other heat exchangers now in use.

Tested and proved under all conditions

Ljungstrom's continuous rotary regenerative principle has been performance-proved for more than 35 years in over 3500 units. The electric utility industry (highly conscious of fuel costs) has virtually standardized on Ljungstroms. *Every* major U.S. utility is Ljungstrom equipped, with some units in continuous service since 1923. Refineries, chemical process plants – even ocean liners and cargo vessels – save fuel with Ljungstroms. For more information on how Ljungstroms can benefit you, write:

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N.Y.

The Pringle Switch with "BOLTED" Pressure silver contacts operates quickly and easily under all conditions. Powerful **bolted** pressure is exerted on the closed contacts with practically no physical effort by the operator.

Find out more about this switch that does a perfect job in your applications every time it's called on to perform. Write for information. Pringle Electrical Manufacturing Company, 1912 North Sixth Street, Philadelphia, Pa.

Pringle

into the press and length of extruded products are considerably increased, raising hourly production to a very high level by press performance of 100 pushes per hr.

The high quality of products obtained by the Ugine-Sejournet process, the regularity of production and the exceptionally high metal yield which can result in an economy of metal of around 10 per cent over traditional rolling mill processes make it highly attractive for the production of seamless tubes. In addition, it is likely that the extrusion process can compete favorably with present processes for production of welded carbon steel tubes of from one to six inches in diameter.

Lorraine-Escaut's new installation at Anzin will be the third glass-lubrified steel extrusion plant in France. CEFILAC, owner of the Ugine-Sejournet process, holds the world record for highest production of extruded stainless steel tubes on a single press in its Persan plant.

The Montbard plant of its licensee, big French tube producer Vallourec, will have the world's largest capacity for production of glass-extruded steel products.

The 4000 ton hydraulic extruding press to be installed in the Lorraine-Escaut plant will be designed and built in France by the engineering department of Vallourec.

Meetings

△ The Galvanizers Committee of the steel industry, sponsored by the American Zinc Institute, will hold its forty-fourth meeting on November 2–3, 1961 at the Sheraton Hotel, Philadelphia, Pa.

△ The Fall Meeting of the National Society of Professional Engineers will be held at the Hotel Roanoke in Roanoke, Va., October 19–21.

△ The Eastern States Blast Furnace and Coke Oven Association will participate in a joint meeting with its companion organization, the Western States Blast Furnace and Coke Oven Association on November 10, 1961 at the Pittsburgh Hilton Hotel, Pittsburgh, Pa.

The regular winter meeting of the Eastern States group is scheduled February 15–16, 1962, at the Penn-Sheraton Hotel Pittsburgh, Pa.

NEWS FROM

LOMA

A wide variety of metallurgical processing work can now be performed by a single mill facility due to the development of this compact and versatile LOMA 2-high/4-high Combination Rolling Mill. The equipment is suitable for both hot and cold work, and allows both shapes and flat stock to be rolled, with or without the application of tension.

The machine is equipped with extra large capacity mill housings, roll journals, universal spindles and drive transmission. This heavy-duty design allows the mill to take reductions of more than 50 per cent per pass while maintaining tolerances as close as 5 per cent of thickness.

Change-over from the 8½ in. x 10 in. 2-high to the 2½ in. & 8½ in. x 10 in. 4-high setup requires only 30 minutes. The 2-high arrangement is used for either hot or cold breakdown rolling of plate and sheet, and grooved rolls are also available to process rounds, squares and other shapes. In the 4-high setup strip is cold finish rolled to gauges as thin as 0.002 in.

The LOMA mill is furnished with high-strength steel housings, twin-handwheel or dual-motor wormdrive screwdowns, universal joint spindles, herringbone gearing, and an extra heavy-duty 25 h.p. variable-speed drive. The rolls are made of forged alloy steel and are hardened to 100 Shore Scleroscope. The roll necks are mounted in super-precision needle roller bearings having a total separating force capacity of 350,000 lbs. The bearings are continuously lubricated by a closed oil circulating system.

LOMA
MACHINE MFG. CO., INC.
114 East 32nd Street
New York 16, N. Y.

Why do we say fulfills the promise

For single function or automated system... our Systemation concept is fitted to your actual needs

In crude definition, automation merely means "to make automatic." In implication, however, automation carries strong promise of low-cost production. It is in the area of lowering costs, some feel, that automation has most frequently missed its potential.

The engineering genius which can concoct sophisticated circuitry . . . join computers, primary detectors, instruments, processing equipment . . . too frequently overlooks the fundamentals of thorough *process knowledge* and such basic problems as the maintenance costs associated with automated systems.

Prudent investment of key importance

The *Systemation* concept is built around lowering *your* processing costs, increasing *your* productivity, improving *your* quality control. The starting point is not "what can be automated" but rather "what automation can be economically justified under your conditions of production."

Allis-Chalmers is thoroughly qualified to help you make *prudent* investment decisions about equipment and instrumentation.

Balanced judgment in depth

Long a supplier of control systems, a broad line of industrial processing and electrical generation, transmission, distribution and utilization equipment, A-C has an intimate knowledge of industrial processes. With the acquisition of Consolidated Systems Corporation last year, Allis-Chalmers extended its ability in the areas of data gathering, handling and utilization. CSC provides such experience acquired from more than 500 successful system projects.

Recently, Allis-Chalmers, Consolidated Systems and International Business Machines Corporation effected a nonexclusive mutual agreement relating to the production and marketing of automated control systems and processes.

For the typical system, Allis-Chalmers takes functional responsibility for the system using IBM data processing computer equipment, CSC specially engineered data conditioning equipment and instrumentation, and A-C basic and auxiliary industrial processing equipment. Now, Allis-Chalmers brings a balance of specialized judgments to bear on your problems . . . drawn on significant experience . . . to make major "contributions to the art" in many phases of *Systemation* and help you be sure before you invest.

Feasibility study shows opportunity

Your first step to Systemation *is a thorough feasibility study which spells out your opportunities for savings and puts a clear figure on the costs. Call or wire your nearest A-C office, or the Industrial Equipment Division, Allis-Chalmers, Milwaukee 1, Wis.*

Systemation is an Allis-Chalmers servicemark.

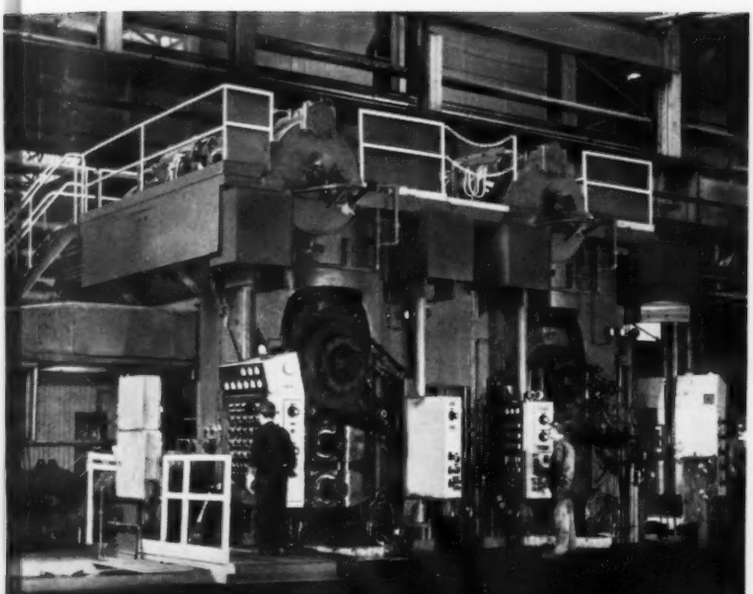
Systemation*

pays its way

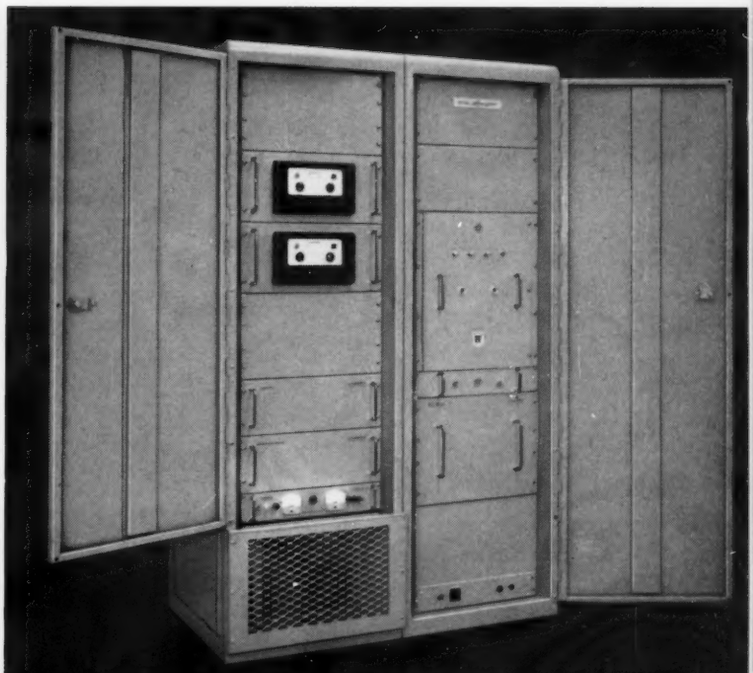
ALLIS-CHALMERS

A-1531

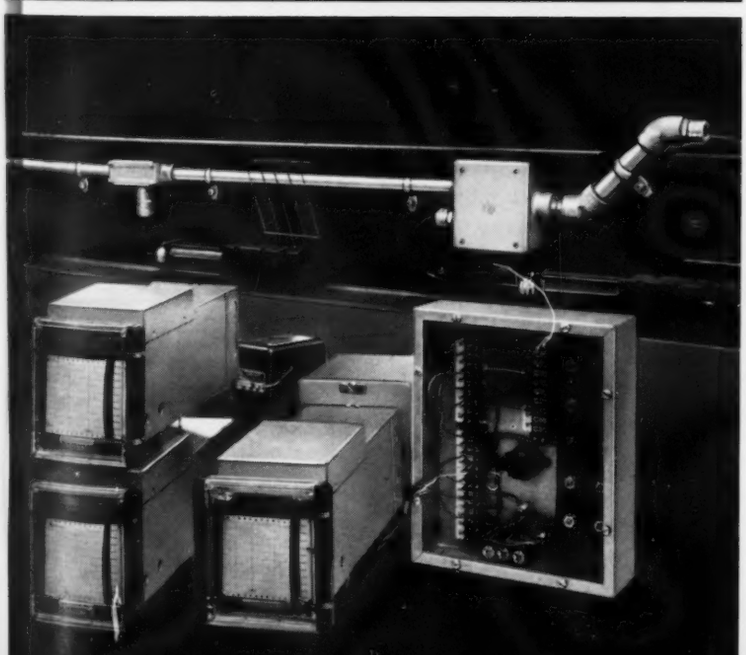
Systemation of automation?



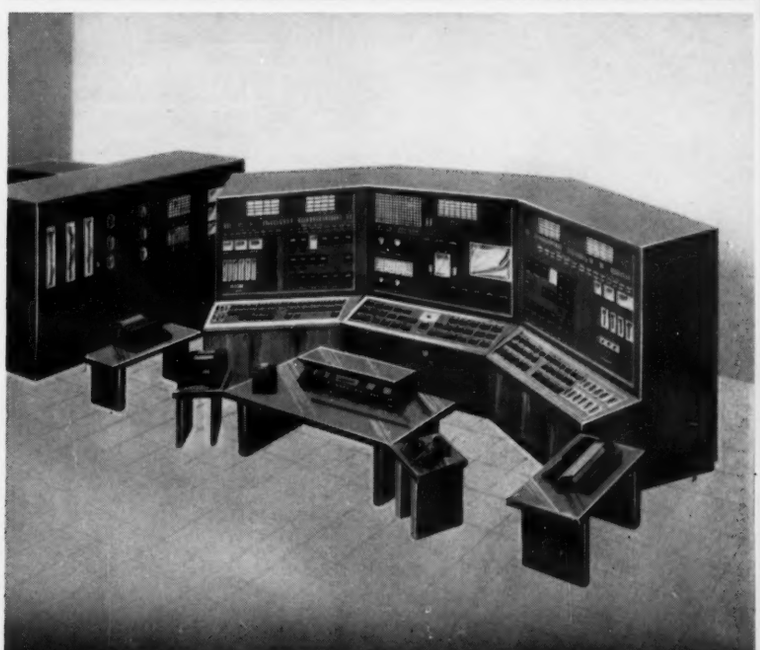
HIGH SPEED TEMPER MILL features include: automatic digital extensiometer to indicate strip extension (hardness pickup); automatic slowdown for rolling maximum length at rolling speed, yet prevent mandrel explosion or tail-end roll damage.



PRECISE AUTOMATIC GAUGE CONTROL for thin tin with automatic screw reset.



AUTOMATIC BED DEPTH CONTROL for traveling grate in GRATE-KILN iron ore pelletizing process.



CENTRALIZED CONTROL ROOM for generating plant using one computer to automatically control two units for start-up, operation and shutdown.

What are the vital savings you want in descaling of strip, sheets, plate, wire rod, structural shapes, slabs or billets? If it's space savings, a Wheelabrator Mechanical Descaler will replace hundreds of feet of pickling tanks. If it's acid elimination, pickling with its attendant problems can be eliminated or radically reduced. If it's savings in metal, Wheelabrator descaling removes scale only. There's no metal loss. If it's cost reductions, a better finish, improved drawing, less handling or more rapid visual inspection, Wheelabrator can give you these savings. Wheelabrator gives you all this plus the Vital Value of experience—of being the initiator of blast descaling, of participating in more installations than any other firm. Ask for "Pictorial Report" Bulletin 156-D.

A demonstration of WHEELABRATOR'S

VITAL VALUES

8 vital savings in steel descaling

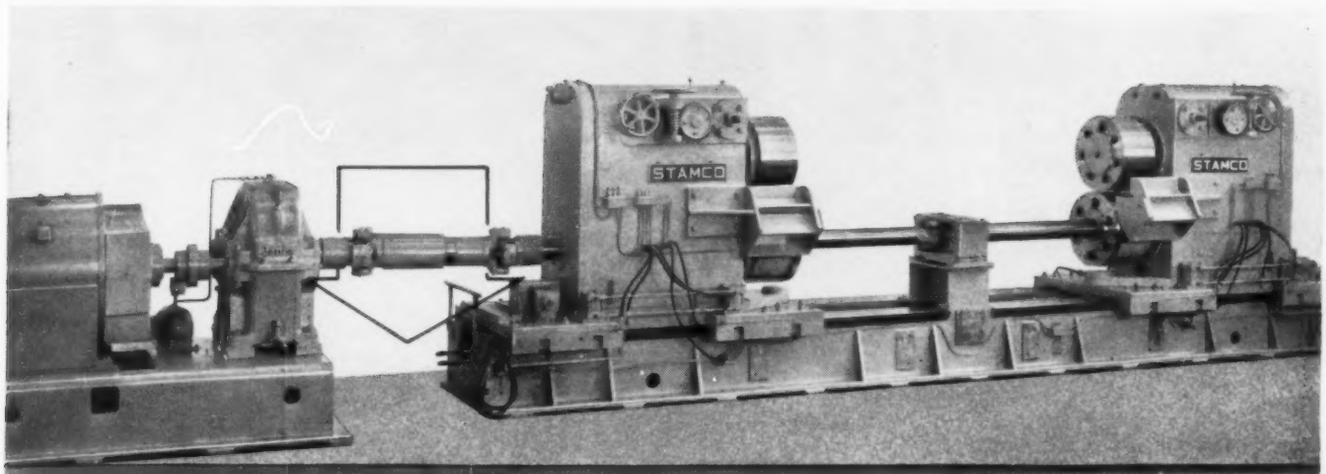
15,500 tons of carbon steel strip a month is Wheelabrator descaled in the modern mill of Altos-Hornos De Mexico SA. Steel is descaled at (up to) 200 f.p.m. contrasted to only 100 f.p.m. by previous pickling method.

VITAL VALUES FOR INDUSTRY

WHEELABRATOR

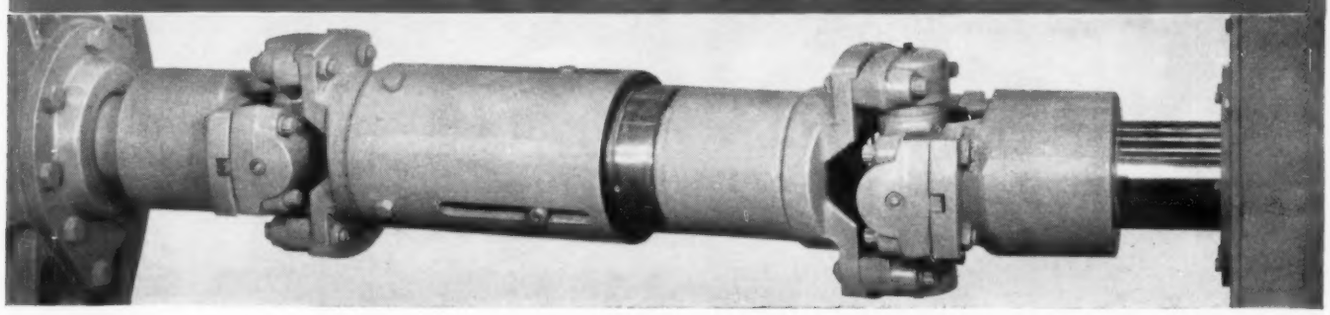
STEEL DESCALING EQUIPMENT

WHEELABRATOR CORPORATION, 386 S. Byrkit St., Mishawaka, Indiana. In Canada, WHEELABRATOR CORPORATION OF CANADA, LTD. 1901 Birchmount Rd. P.O. Box 490, Scarborough, Ontario
A subsidiary of Bell Intercontinental Corp.



BLOOD BROTHERS "150WB" UNIVERSAL JOINT

MADE THIS STAMCO HOT MILL SIDE TRIMMER POSSIBLE



This Mammoth, custom-built Stamco machine weighs 85,000 pounds. Equipped with 24-inch diameter cutters and star type scrap choppers it can make two cuts of .300-inch in hot aluminum at the amazing rate of 1200 feet per minute!

During design stage, Stamco ran into a power transmission problem they had never encountered before. The coupling housing not only moved in and out for width but also had an angular movement of 3°. A coupling was needed to withstand heavy wear as well as the strain of the angular movement.

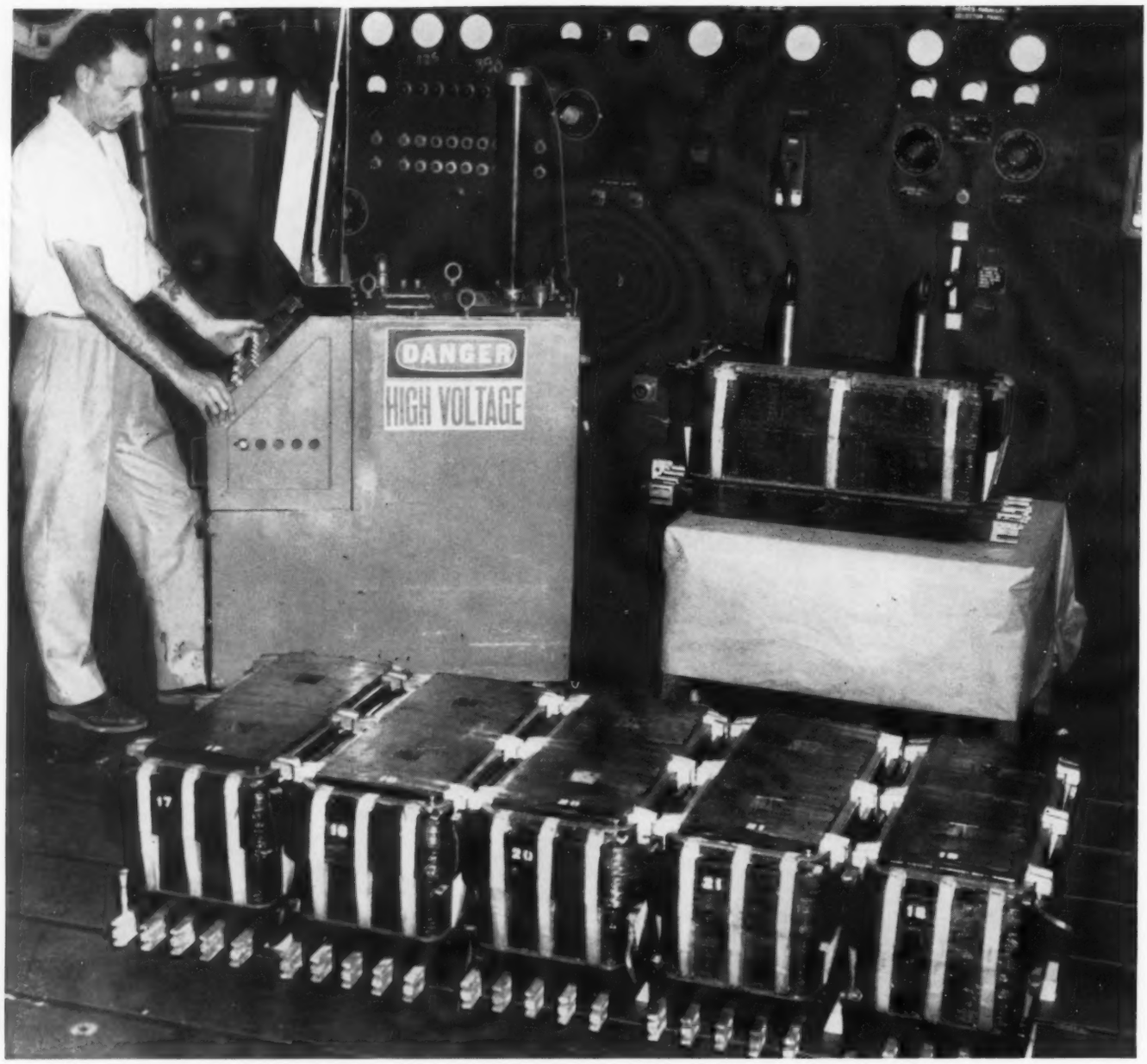
Stamco called in Rockwell-Standard engineers who recommended their largest universal joint, the Blood Brothers "150WB." The "150WB" easily handles 162,000 inch pounds of torque using a safety factor of 10 to 1 . . . in a swing diameter of only 13½ inches! A specially-designed "150WB" solved Stamco's problem, enabled them to satisfy their customer with a dependable, big-capacity unit.

Rockwell-Standard specialists can design and build *any* universal joint you need. Their wide experience and complete manufacturing facilities assure you of the most efficient performance at the most favorable price. Call or write today for further information.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

ROCKWELL R STANDARD

Universal Joint Division, Allegan, Michigan



NATIONAL COIL'S TESTING KNOW-HOW HELPS ECONOMIZE ON FIELD COIL RECONDITIONING

These field coils for a 3500-hp D.C. steel mill motor were reconditioned by National on a rush basis—10 days from pick-up to delivery. The work included cleaning and testing, dipping and baking, and replacement and reinsulation where required.

Despite the rush nature of the job, National applied its usual thorough testing. Considerable savings resulted to the customer. The customer had made a-c tests in his mill indicating pole face windings were OK but National also made d-c polarization index tests showing insulation was not satisfactory. After thorough drying, varnishing and baking, further tests assured insulation was fully restored without replacement.

In this application, National's know-how prevented future trouble—but avoided the expensive way of correcting it. The same know-how can assure you of maximum dependability on your coil or rebuilding jobs. For information contact National's Columbus plant . . . HUdson 8-1151 . . . or check the nearest National field engineer.

DIVISION OF

National Electric Coil

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

McGRAW EDISON

Now leading steel producer reports

ALEMITE OIL-MIST WITH THERMO-AIRE® CUTS HOT STRIP MILL LUBRICATION COST 90% ON WORK ROLL BEARINGS!

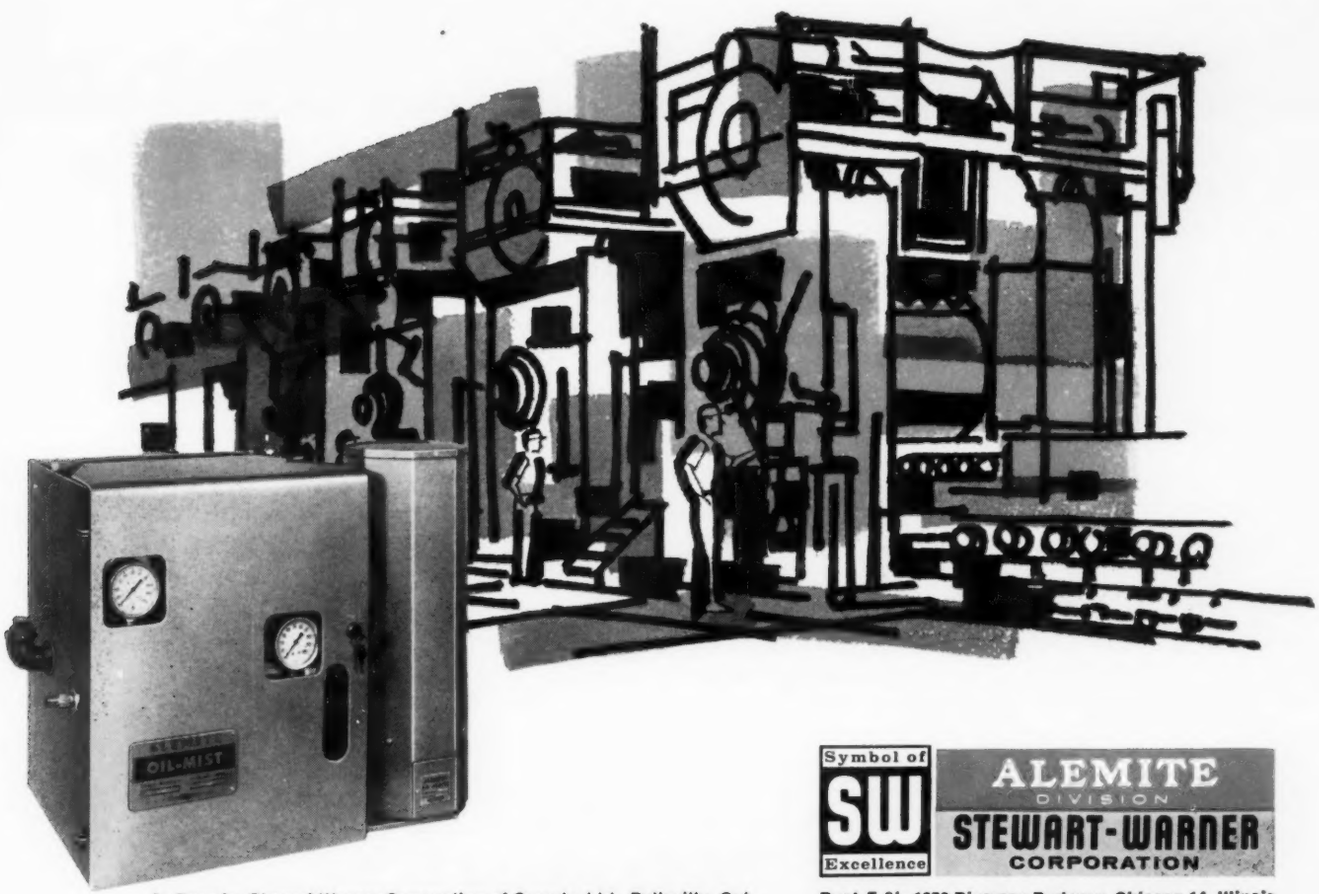
There is no comparison between Alemite Oil-Mist with Thermo-Aire and old-fashioned grease methods!

Take economy. Lubrication savings amount to $32.00 on every turn with Alemite Oil-Mist with Thermo-Aire. Oil-Mist was installed on one stand . . . and is being installed on nine other stands to replace an out-dated system for lubricating 40 roller bearings on an 80-inch hot strip mill. Working 15 turns a week, 52 weeks, these savings will add up to nearly $25,000 a year!

Take efficiency. Alemite Oil-Mist with Thermo-Aire is a fully automatic lubrication system. It applies lubricants constantly, properly, *without losing a minute of valuable production time.* It eliminates expensive packing of bearings with grease and also completely eliminates need to clean bearings of old grease. Its exclusive "Thermo-Aire" feature preheats incoming air—permits atomization of even the heaviest straight mineral oils to supply heavy-duty bearings with the high viscosity lubricants they need for smooth, steady performance.

Alemite Oil-Mist with Thermo-Aire will improve mill operating efficiency... lengthen bearing life . . . cut oil consumption and prevent product spoilage.

Write for illustrated brochure form 37-32, or see your Alemite representative for the amazing story of Alemite Oil-Mist with Thermo-Aire and how you can benefit from it!



Symbol of SW Excellence

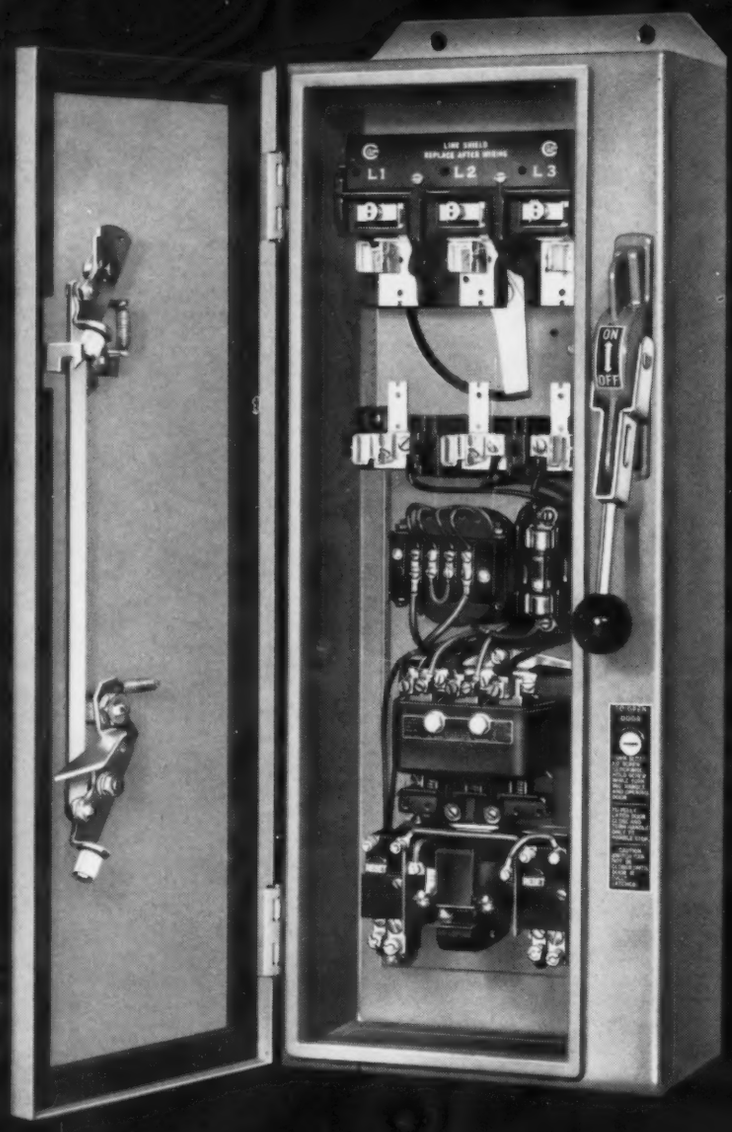
ALEMITE DIVISION
STEWART-WARNER CORPORATION

In Canada: Stewart-Warner Corporation of Canada, Ltd., Belleville, Ont.

Dept. F-91, 1850 Diversey Parkway, Chicago 14, Illinois

NEW
FROM CLARK

NEMA 12 SAFETY COMBINATION STARTERS WITH THREE EXCLUSIVE FEATURES



Safety fusible combination starters are gaining wide interest throughout industry. But only the new Clark line offers these important features:

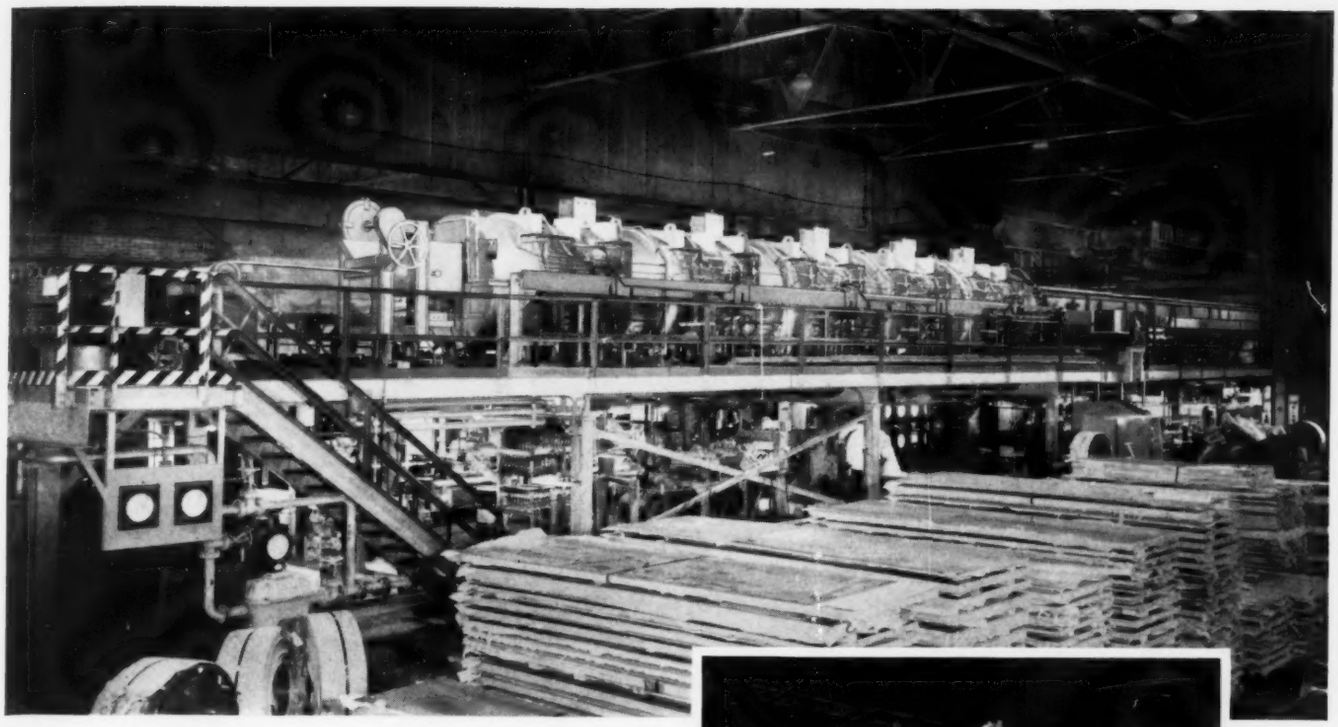
- *New Clark-built visible blade disconnect switch with double-break, silver-alloy to silver-alloy contact surfaces*
- *Disconnect switch accommodates NEC or the new Class J Current Limiting fuses*
- *To simplify installation, complete unit can be removed from enclosure in seconds with no disassembly of handle mechanism*

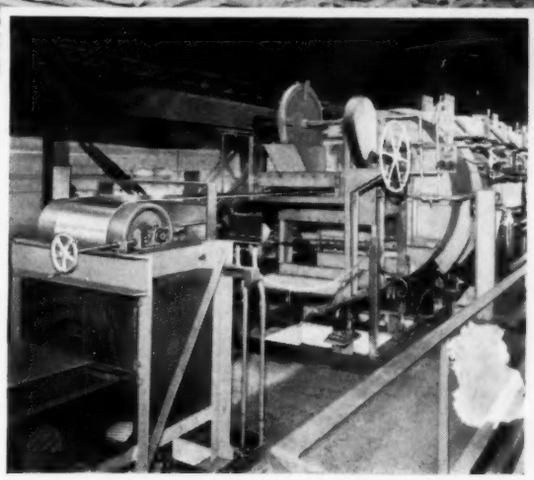
New Clark Safety Starters offer non-teaseable, snap-action disconnect switch operation. Cabinet design permits only authorized persons to open door when switch is on, or to close switch when the door is open. Dust-tight operation is assured by interlock which requires door handle to be closed and door tightly latched before disconnect switch is operable.

These Clark Safety Fusible Combination Starters are available with interchangeable fuse clips to accommodate a full range of fuses, and are offered with famous Clark "CY" Contactors in sizes 0, 1, and 2. Designed for NEMA 12 (industrial) service, they also are suitable for NEMA 5 (dust-tight) applications. For information, call the nearest Clark distributor or sales office, or write: 61SCS1

THE CLARK CONTROLLER COMPANY

MAIN PLANT: CLEVELAND, 10 • **WESTERN PLANT:** LOS ANGELES, 58
IN CANADA: CANADIAN CONTROLLERS, LIMITED, TORONTO, ONT.





EF Furnace

Bright Annealing Stainless Strip at Armco Steel

• The No. 18, 24" wide Stainless Strip Bright Annealing Line at Armco's Butler, Penna. Works, pictured above, is one of 25 coating, silicon and bright annealing lines, designed and built by The Electric Furnace Co., installed in various Armco plants. Like several other EF horizontal bright annealing lines, the furnace and cooling sections are mounted on a balcony. This permits the pay-off reel, coiling reel and control equipment to be installed under the furnace, saving floor space and minimizing building changes.

EF Stainless Strip Bright Annealing Furnaces produce a durable, mirror finish on trim stock and other stainless strip *without chrome depletion*. The Electric Furnace Co. has designed and built *23 stainless strip bright annealing lines;* this is more than any other manufacturer. Included are both horizontal and vertical type furnaces, fuel fired and electrically heated.

For the highest finish, the most durable corrosion resistant surface, and the most experience in bright annealing stainless strip, you too will find that "it pays to call the EF furnace engineers".

THE ELECTRIC EF FURNACE CO.
GAS · OIL · ELECTRIC

THE ELECTRIC FURNACE CO.

Fuel Fired and Electrically Heated
HEAT TREATING FURNACES
for Processing any Product, in any Atmosphere, any Hourly Output Required

Salem - Ohio

SUBSIDIARIES—Turnkey Engineering Co., Inc., South Gate, Cal. • Canefco Limited, Scarborough, Ontario
SALES REPRESENTATIVES—2842 West Grand Blvd., Detroit 2, Mich. • also 968 Coleman Rd., Cheshire, Conn.

STAINLESS *"Takes A Shine"* TO ITS WORK

—in transportation, building, communications

and when you're producing stainless steels GLC ELECTRODES WILL IMPROVE FURNACE EFFICIENCY

Modern electric steel furnaces demand more from electrodes than ever before.

GLC electrodes are meeting these strict requirements by setting new records for efficient operation, reduced down-time, increased production.

When you specify GLC electrodes, you are assured of outstanding value in trustworthy product performance and prompt, conscientious service.

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In May, 1961:

two major achievements
in Sendzimir
coating lines:

The world's largest

AT ARMCO STEEL CORPORATION

The world's fastest

AT YOUNGSTOWN SHEET AND TUBE COMPANY

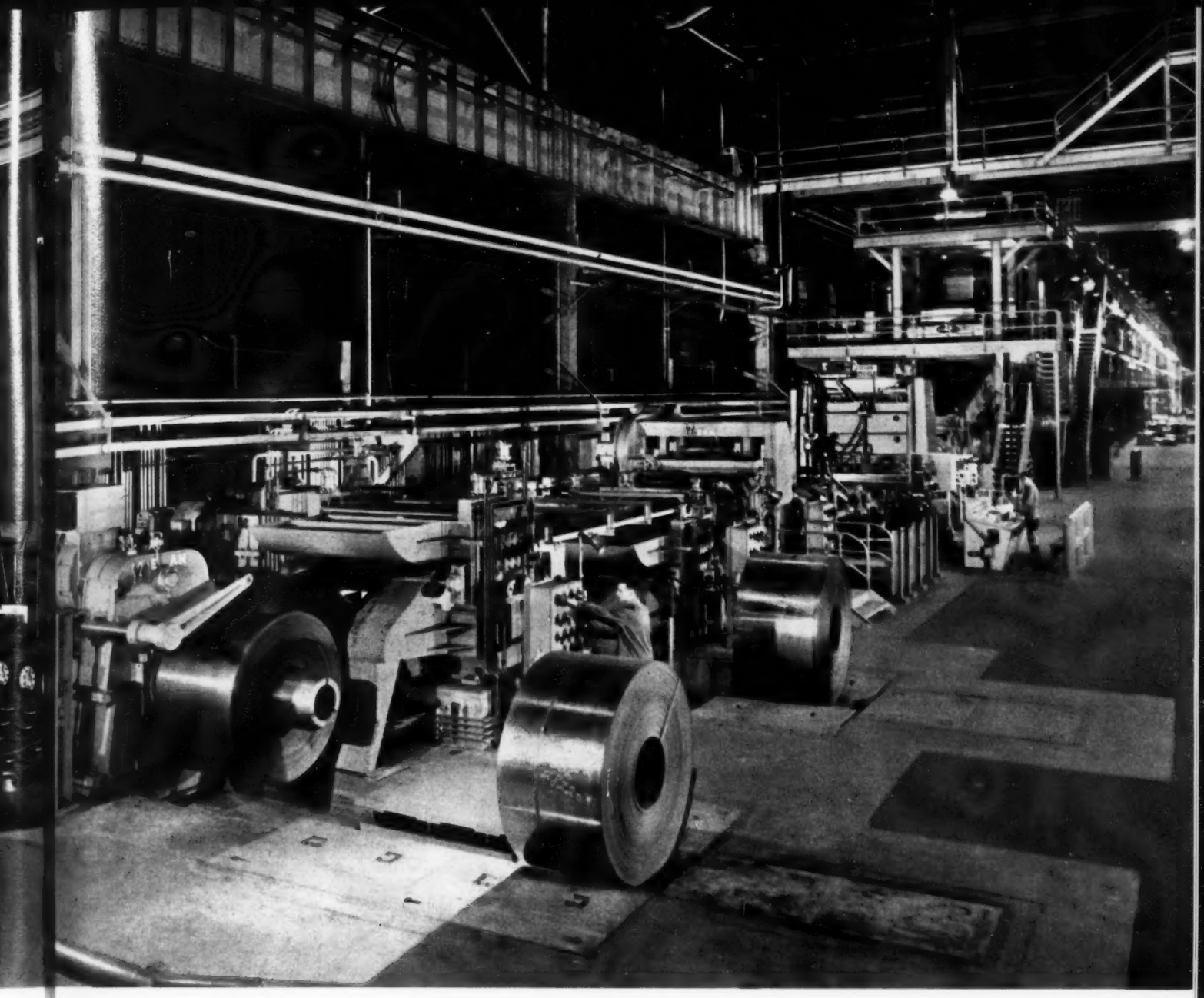
Both lines
built by
WEAN

72″

Armco Steel Corporation

The widest coating line in the world at Armco's Middletown Works turns out zinc-coated steel coils and sheets up to 72″ in width. In addition to permitting Armco Division to meet growing demand for zinc-coated steels, this new **Wean-built** line will open many new design possibilities to Armco's fabricating customers by giving them greater dimensional latitude than ever before available.

Designed to handle strip from 11 through 22 gauge, the line employs the Armco-Sendzimir process of annealing and coating in one continuous operation.

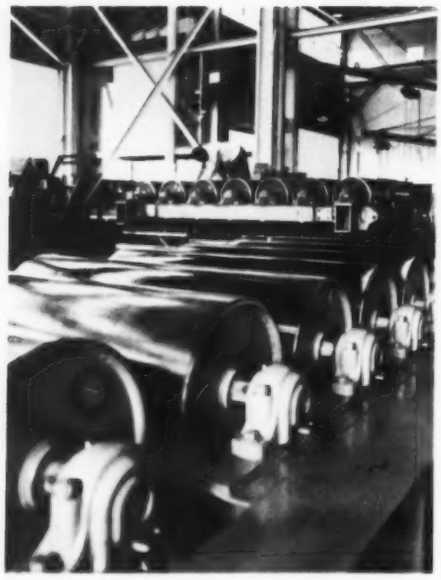


400 fpm

Youngstown Sheet and Tube Company

The world's fastest Sendzimir coating line was installed by Youngstown Sheet and Tube Company at its Indiana Harbor works. Constructed by **Wean Engineering,** this line is designed to operate at speeds up to 400 feet per minute, and to handle strip widths up to 62″, and gauges ranging from 10 through 30.

Youngstown's new 848-foot line incorporates every modern facility, insuring superior quality zinc-coated sheets in both cut-lengths and coils; flat or corrugated.



Planning new strip processing facilities? Talk to Wean . . .

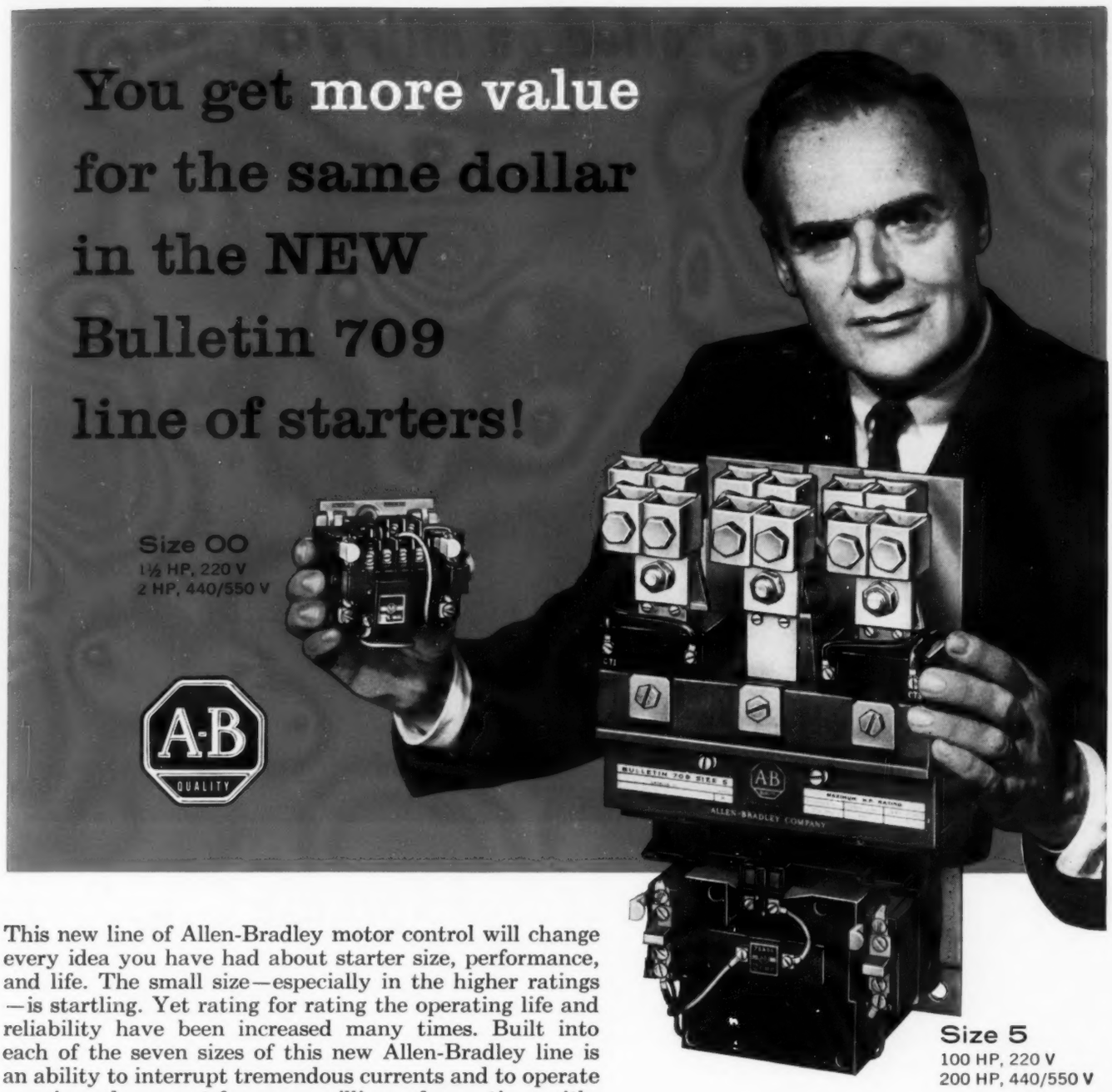
During this period of growing competition among producers of finished steel products, Wean has led the industry in the development of more efficient continuous processing facilities, designed to turn in additional profits for steel producers.

Wean processing equipment is precision-engineered and built to meet your exact requirements, the result of close coordination between our specialists and your engineering department, use of modern techniques by our experienced design staff, and the facilities of our specialized manufacturing operation.

Why not put this background of "creative engineering" know-how to work at improving profits in your continuous processing operation?

THE WEAN ENGINEERING COMPANY, INC. • WARREN, OHIO, U. S. A.

You get more value for the same dollar in the NEW Bulletin 709 line of starters!



This new line of Allen-Bradley motor control will change every idea you have had about starter size, performance, and life. The small size—especially in the higher ratings—is startling. Yet rating for rating the operating life and reliability have been increased many times. Built into each of the seven sizes of this new Allen-Bradley line is an ability to interrupt tremendous currents and to operate year in and year out for many millions of operations without trouble or maintenance.

The new Bulletin 709 starters are just as advanced in appearance as they are in performance. All seven sizes have an aristocratic styling and a distinctive family likeness. Brooks Stevens, famous industrial designer, has given the enclosures such an attractive, modern style that these new starters will prove a distinct sales asset on any machine or installation.

Why not write today for more information on this revolutionary new line of Allen-Bradley Bulletin 709 *quality* across-the-line motor starters?

Note the compactness of both the smallest and largest starter in the new Bulletin 709 line. Ratings up to 100 hp, 220 v; 200 hp, 440-550 v.

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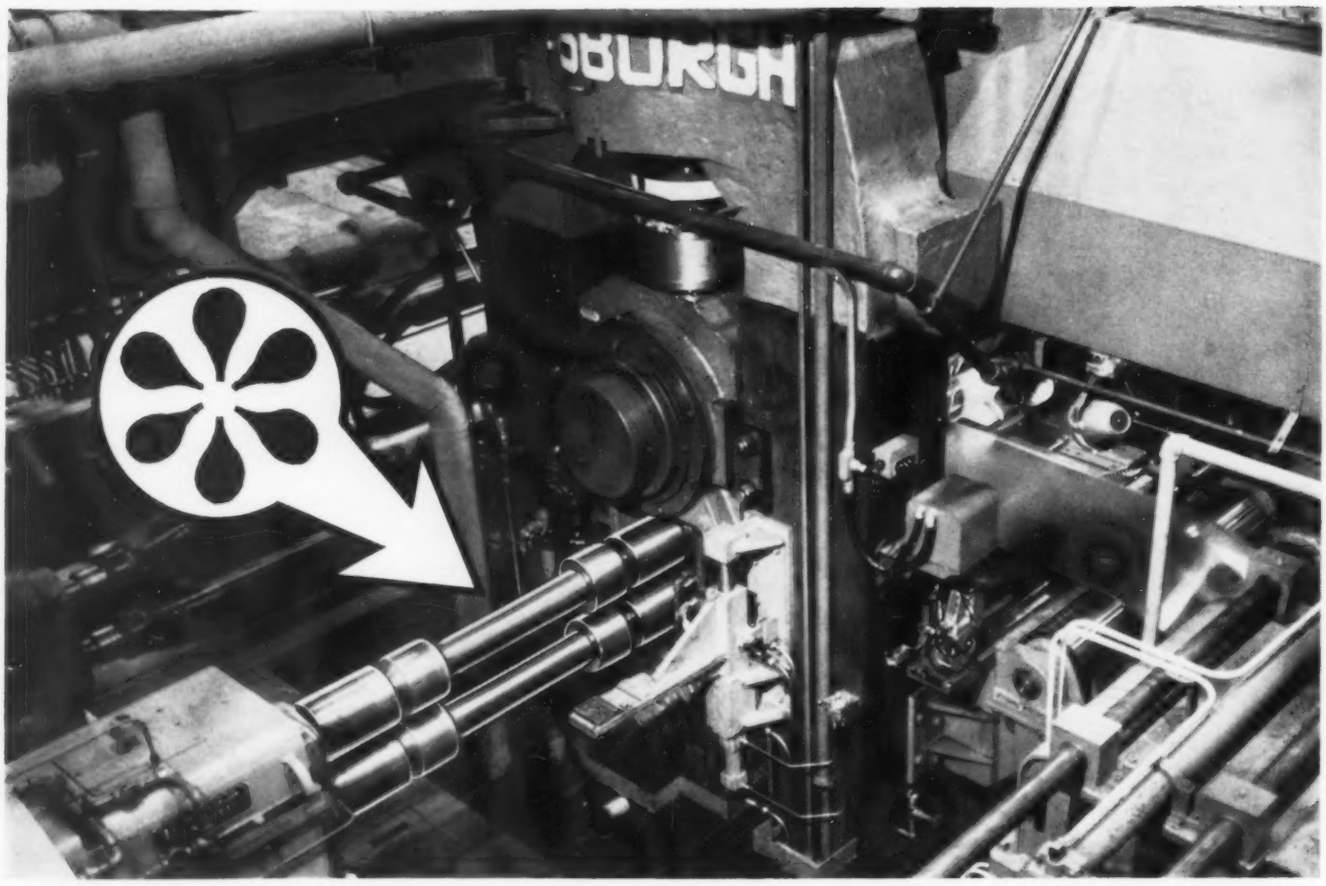
QUALITY MOTOR CONTROL

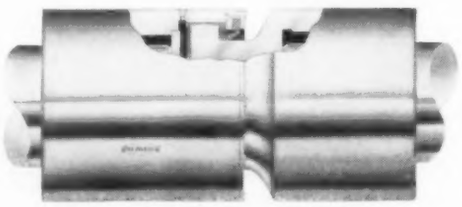
Miles of Sheet Rolled on Mill Driven by



AJAX Dihedral Spindle Couplings

Around the clock production of tons of Anaconda Aluminum sheet depends on Ajax Dihedral Spindle Couplings delivering the power to this mill built by Pittsburgh Engineering & Machine division...*a Textron Company.*

They are driving this 12x38x66 four-high cold mill *at Anaconda Aluminum's Terre Haute plant* and turning out miles of sheet with accurate gauge and thickness and excellent surface finish.



The ability of Ajax Dihedral Spindle Couplings to handle various offset and angular requirements at constant peripheral speed has established new standards of output and quality control.

As this on-the-job photograph shows, Ajax sealed-in lubrication insures good housekeeping in the shop as well as long life performance.

Hundreds of Ajax Dihedral Spindle drives are increasing production and cutting maintenance costs in mills throughout the world.

Mill builders and mill owners are invited to take advantage of our broad experience gained in designing couplings for a wide variety of ferrous and non-ferrous mills. Consult the yellow pages or write for Bulletin 70.

AJAX FLEXIBLE COUPLING CO. INC.

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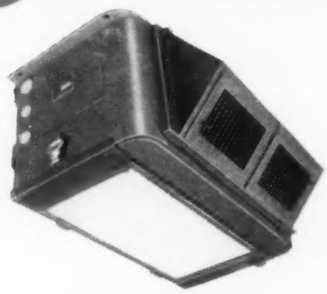
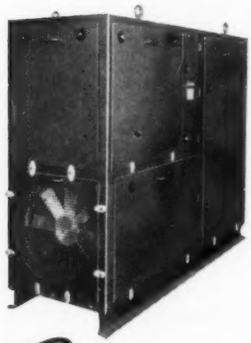
Even in Hot Locations Like This





This cab is Lintern air conditioned. Thousands of crane cabs and pulpits are. And the amazing thing is how little service is needed in spite of the extreme mill conditions which these air conditioners must overcome. Lintern equipment has been tested over soaking pits for more than 20 years. You can depend on it to perform well, increase operator efficiency, boost production, and net you a greater return on your capital investment.

More Lintern *Aire Rectifiers cool more cabs and pulpits than any other make.*

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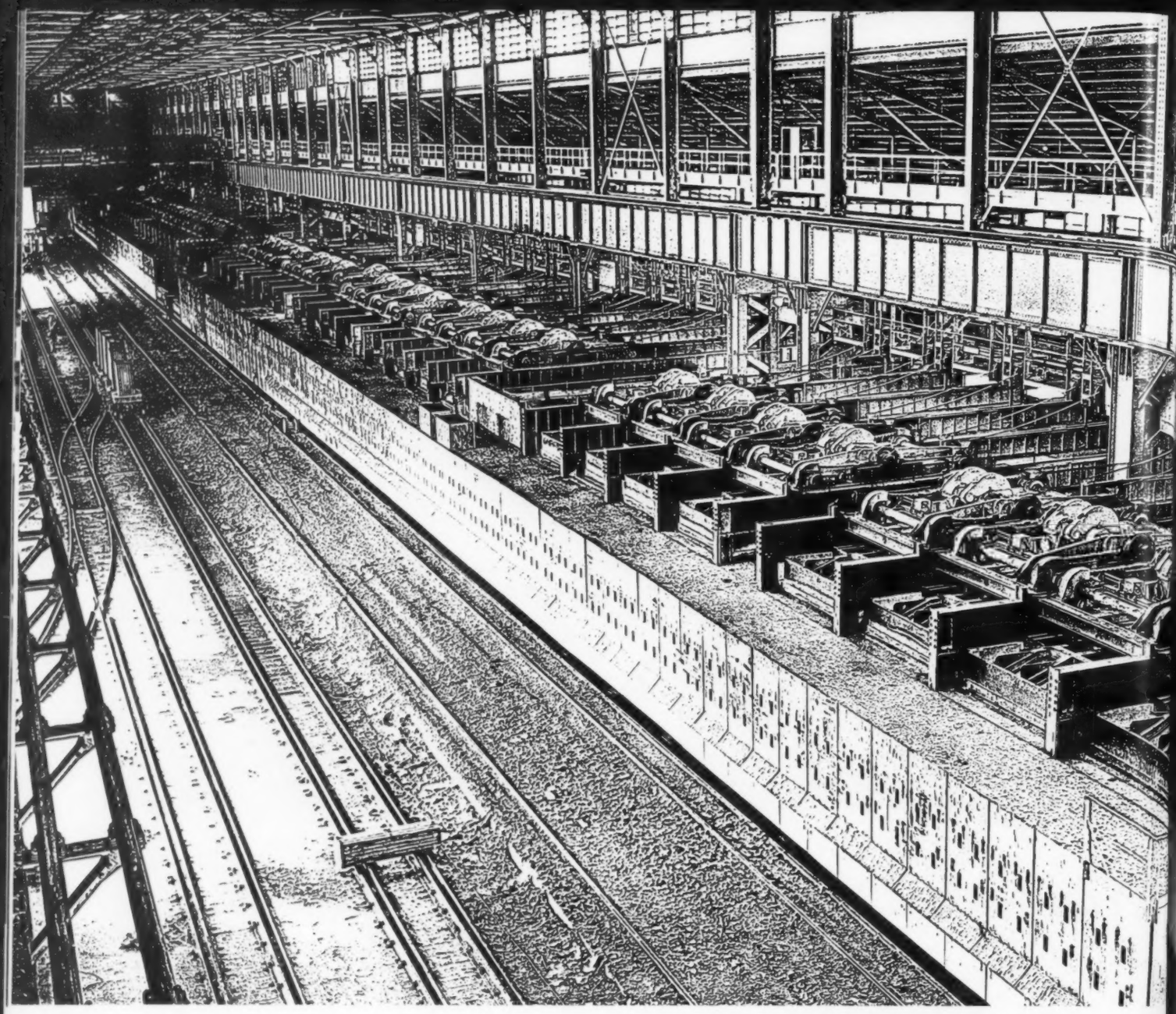

Courtesy of Gary Works, U.S. Steel Corporation

Gets them out the back door (750 tons/hr) This is the largest installation of soaking pits (48) ever built at one time. Engineered by Surface, it will heat an average of 750 tons per hour. At peak capacity, it loads the ingot buggies at a rate of 1200 tons per hour. A dual recuperator system applies the maximum amount of heat where it belongs—inside the pit. Address inquiries to 2404 Dorr St., Toledo 1, Ohio.

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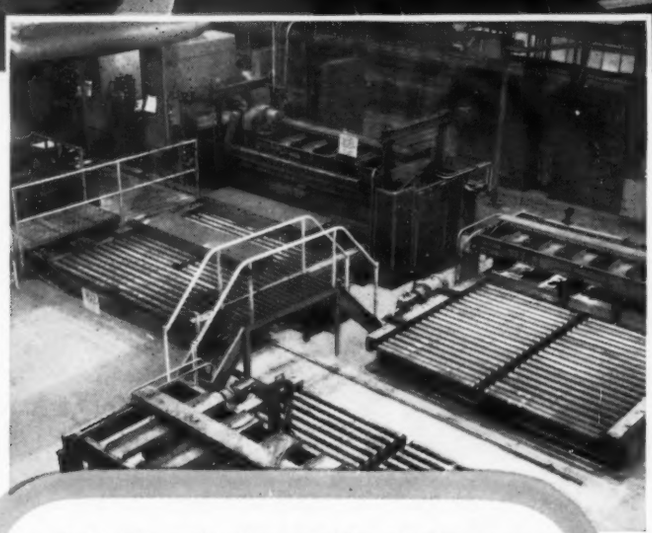
Magnetic Feeding and Stacking Equipment

Feeder handling sheets at coating line for major midwestern appliance manufacturer.



Partial view showing roughing stacker, transfer mechanism and finish feeder for fully automated bumper polishing line in plant of a leading automobile manufacturer.

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What good steel rolls are made of

Proper ingredients, modern facilities, experienced people and quality control . . . this is what steel rolls are made of at National Roll. They start with the careful selection of the correct steel analysis to suit your application. Then, men like Works Manager Jack Russell, pictured above, carefully control the quality of your rolls from electric furnace melt to turning and grinding. Why not see for yourself what good rolls are made of at National—whether steel, iron or nodular iron. A look at our facilities and a talk with our people will show you why . . . NATIONAL'S THE GROWING NAME IN ROLLS.

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GENERAL STEEL INDUSTRIES, INC., Avonmore, Pennsylvania
General Steel Industries, Inc., General Offices: Granite City, Ill. Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.
Subsidiary: St. Louis Car Company, St. Louis, Mo.

Personnel News...

William E. Mullestein has been appointed vice president and general manager, Lukens Steel Co. He has been vice president—administration since 1957.

L. P. McAllister was elected vice president—production, Lukens Steel Co. Mr. McAllister joined Lukens in 1922 and progressed through departments in the operating organization to the position of manager of steel plants, and then in 1957 to general manager of production.

Richard F. Armitage has been named manager of Republic Steel Corp.'s Warren, Ohio, district, succeeding **R. C. Gintert** who is retiring after 44 years of service with the company. Mr. Armitage joined Republic's Chicago plant in 1933 as a lubrication engineer. He also served as combustion engineer and general millwright foreman at the Chicago plant. He was transferred to Warren in 1946 as assistant mechanical superintendent and became superintendent of the Mechanical Department two years later. He was appointed superintendent of construction in 1956 and general superintendent in 1958. The following year he was made assistant district manager, his most recent position. Mr. Gintert joined the Trumbull Steel Co., a predecessor company of Republic, in 1917. He started in the Shipping Department and subsequently became general foreman of the 42-in. hot strip mill in 1927. He became superintendent of hot strip rolling in 1937 and in 1946 moved to Cleveland as general superintendent of Republic's 98-in. strip mill. He returned to Warren in 1953 as district manager.

Arthur A. Kappenhagen has been appointed assistant manager of the Warren district, succeeding Mr. Armitage. Mr. Kappenhagen joined Republic in Cleveland in 1935 as a turn foreman in the Labor Department. He later served as dock foreman, assistant labor superintendent and assistant superintendent of the Open Hearth Department at the Cleveland plant. He was transferred to the company's steel plant at Youngstown, Ohio, in 1953 as superintendent of the Open Hearth Department. He became division superintendent of the Youngstown steel plant in 1957 and in 1959 moved to the company's Chicago plant as general superintendent, the position he held until taking over his new duties.

George M. Burrier was named to the post of assistant general manager in charge of primary production at the Indiana Harbor works of Inland Steel Co. Mr. Burrier was formerly works manager of the Crucible Steel Co. of America's Midland, Pa., works and has 29 years experience in the steel industry. He succeeds **Louis R. Berner** who retired recently after 43 years with Inland. Mr. Burrier began his steel career in 1932 at the Youngstown Pressed Steel Co. in Warren, Ohio. After one year as assistant to the production manager in Warren, he moved to the Republic Steel plant in Youngstown, Ohio. In his eight years with Republic at Youngstown he worked his way through open hearth production assignments to the post of melter, the job he held when he was promoted to assistant superintendent of open hearths of Republic's Chicago works. He moved to Republic's general offices in Cleveland in 1949 as secretary of the firm's corporate-wide open hearth committee and accepted an appointment as assistant works manager at Crucible's Midland works the following year. He was named works manager at Midland in 1957.

J. Rodgers Hamilton has been appointed to the newly-created post of manager of customer technical service for United States Steel Corp.'s central operations. Mr. Hamilton, who has been manager of structural, plate and high-strength steel metallurgy, will direct and co-ordinate the activities of four area managers and supporting field personnel who will be available throughout the corporation's sales districts to give customers immediate technical counsel. Mr. Hamilton joined U. S. Steel as a metallurgical observer at the corporation's Homestead district works in 1935. He served subsequently as a metallurgical inspector and inspector foreman at Homestead, and in 1940 he was

W. E. MULLESTEIN

L. P. McALLISTER

R. F. ARMITAGE

A. A. KAPPENHAGEN

J. O. DAGUE

E. L. WEDEN, JR.

G. J. ERDOS

W. R. DuCHANOIS

assigned to the Metallurgical Department at the corporation's Pittsburgh headquarters where he was a service metallurgist. After a brief tenure as a metallurgical inspector at Irvin works, Mr. Hamilton returned to the headquarters' Metallurgy Department where he held a succession of jobs as service metallurgist handling alloy products. He was transferred in 1948 to Cleveland as resident service metallurgist and to Chicago in 1951 as supervisor of services for railroad products. In 1955, he returned to Pittsburgh as assistant manager of the structural, plate and high-strength steel section, metallurgical division. In 1960 he was named manager, the position from which he has just been promoted.

James O. Dague, formerly an assistant general manager of the Steelton, Pa., plant of Bethlehem Steel Co., has been appointed general manager. He succeeds **Walter B. Lang,** who is retiring after 44 years of service with the company. Mr. Dague joined Bethlehem as a member of the 1937 Loop Course, and was assigned to the Bethlehem, Pa., plant. Later that year he was transferred to the Mechanical Department of the Lackawanna, N. Y., plant. He became turn foreman in 1939, and outside foreman in 1940. He was then assigned to the Rolling Mills Division, and was named master mechanic of the 40-in. mills later that year. In 1945 he returned to the Mechanical Department as general foreman. In 1947, he was appointed assistant superintendent of the Coke Oven Division. In 1949, he became assistant superintendent of the Mechanical Department, and superintendent in 1956. He was transferred, earlier this year, to the Steelton plant as an assistant general manager. Mr. Lang joined Bethlehem as an assistant millwright in the Forge Department of the Steelton plant in 1917. He became master mechanic in 1920, superintendent in 1934, and assistant general manager in 1940. In 1947, he was named general manager.

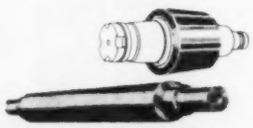
E. L. Weden, Jr., has been appointed general superintendent of Republic Steel Corp.'s Youngstown, Ohio, district. **G. J. Erdos** succeeds him as superintendent of the continuous weld tube mills. **R. J. Silvashy** succeeds Mr. Erdos as assistant superintendent of the continuous weld tube mills. **W. R. DuChanois** will be superintendent of the Transportation and Labor Department, succeeding the late **T. S. McLaughlin. W. K. Bonte, Jr.,** replaces Mr. DuChanois as assistant superintendent of transportation and labor. Mr. Weden joined Republic in 1936 as a weighmaster in the Accounting Department of the Youngstown plant. He subsequently served as a scaleman, end welder, control man and turn foreman in the Welding Division of the continuous weld tube mill. He also served as general foreman and assistant superintendent of the continuous weld tube mill before being named superintendent of the department in 1952. Mr. Erdos started with Republic as a foreman in Canton in 1945. He was transferred to Youngstown in 1947 and served as general foreman for five years in the Galvanizing Department and five years as general foreman in the Finishing Department of the butt and continuous weld tube mill. He became assistant superintendent in 1957.

Roland M. Miller has been named superintendent of the Electrical Department of the Massillon, Ohio, plant, Republic Steel Corp. He succeeds **James D. Kelvie,** who has retired after 39 years of service with Republic. **Charles K. Pickering** has been appointed superintendent of the Electrical Department of the Canton plant, succeeding **Zeb W. Whitehouse,** who has retired after 43 years of service. **Joseph R. Fashbaugh** succeeds Mr. Pickering as assistant superintendent of the Electrical Department at Canton. **Richard A. Hershey** has been named assistant chief engineer of Central Alloy District, succeeding **O. M. Schulze,** who concluded 35 years of service with Republic when he retired recently. Mr. Miller has been with Republic in Massillon since 1951. He started as electrical foreman in the Furnace Division and was named assistant superintendent of the Electrical Department in July last year. Mr. Pickering has been with Republic more than

R. M. MILLER

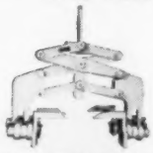
C. K. PICKERING

Heppenstall
and
Midvale-Heppenstall roll it, cut it, handle it



Back-up roll sleeves and forged hardened, ground rolls

Crop shear knives



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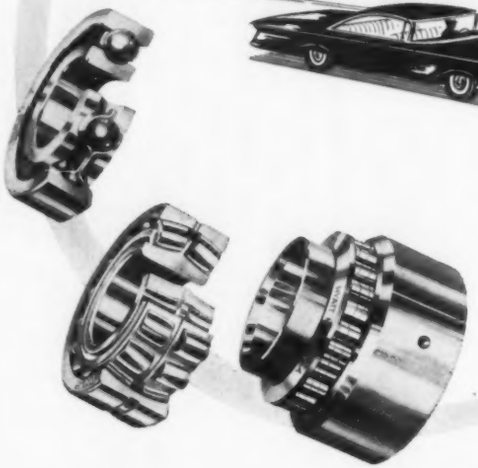

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J. T. MAYHEW

B. W. JONES

A. J. MacDONALD

MALCOLM MARTIN

20 years at the Canton plant. He started as a helper in a line gang and later was a wireman before being selected to participate in the company's technical operating training program. After completion of the program, he was appointed substitute foreman. In 1951, he was named general foreman of the Electrical Department, and he has been assistant superintendent since January last year.

John T. Mayhew has been named manager of Weirton Steel Co.'s Sheet Mill. **Benjamin W. Jones,** formerly galvanize superintendent in the Sheet Mill, succeeds Mr. Mayhew as assistant manager. **A. John MacDonald** was named superintendent of the Sheet Mill, a new position to which he was advanced from Sheet Mill metallurgist. Mr. Mayhew first worked for Weirton Steel in 1923. In 1931, he was transferred to the Strip Steel Department as pickler superintendent. Five years later he was named assistant galvanize superintendent in the Sheet Mill, was promoted to galvanize superintendent in 1941 and became assistant manager in February of this year. Mr. Jones began his Weirton career in 1925 as an assistant recorder in the Blooming Mill. In 1929, he became Hot Mill weighmaster in the Sheet Mill, was named shearing and opening foreman in 1933, turn foreman in 1937 and galvanize weighmaster in 1941. Mr. Jones moved up to galvanize inspection foreman in 1945. He was named general foreman of the Galvanize Department in 1958 and galvanize superintendent last February. Mr. MacDonald came with Weirton as a first class tester in the Metallurgical Department in 1953. From that position he moved to assistant senior metallurgist in the 10–16-in. Cold Mill, Strip Steel Department; then to Steel Works metallurgist; and to Sheet Mill metallurgist, the position he held at the time of his current appointment.

Malcolm Martin has been named superintendent, Coke and Chemicals Department, Alan Wood Steel Co. He was formerly with American Steel and Wire Division of United States Steel Corp., Cleveland, Ohio, where he held the position of general foreman.

Carl J. Gustafson, director of mechanical maintenance, Pueblo, Colo., plant, Colorado Fuel & Iron Corp., retired recently after nearly 40 years of service.

Harry R. Meyer, assistant to the vice president—administration of Lukens Steel Co. since 1957, has been appointed to the position of purchasing agent.

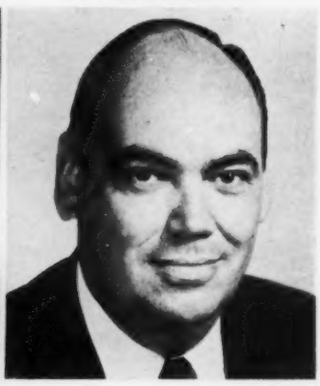
Charles P. McShane has been appointed Crucible Steel Co. of America's manager of technical services, tool steels. He was formerly customer technical service engineer for the Midwest area. Mr. McShane joined Crucible in 1939 at the company's Sanderson-Halcomb works in Syracuse, N. Y. He served in various metallurgical and sales capacities before his transfer to the Company's Chicago sales branch in 1956. In January, 1961 he became customer technical service engineer, the position he held until his present appointment.

Edward K. Barney has been appointed assistant general superintendent of the Baltimore, Md., works of Armco Steel Corp. Formerly assistant to the general superintendent, Mr. Barney joined Armco at the Baltimore works in 1938. He held a variety of assignments in operating departments. In 1948, Mr. Barney became a foreman in the Metallurgical Department and that same year was promoted to suggestion system coordinator and apprentice training supervisor. He was named assistant supervisor of personnel relations in 1954, and assistant to the general superintendent in 1959.

Curry E. Ford has been named director of development for National Carbon Co., Division of Union Carbide Corp. He succeeds **Carl A. Odening,** who has been appointed administrative assistant in the office of the president. Mr. Ford joined National Carbon in 1937, and was active in the development of carbon and graphite chemical process equipment. In 1953 he was named manager of chemical products sales. He was appointed new products marketing manager in 1957, and since

C. E. FORD

W. C. McCOSH



E. G. KONDAS

C. E. ANDERSON

G. C. CAMPBELL

E. R. MACKEY

1960, has been director of marketing. **William C. McCosh** has been named director of marketing for National Carbon Co., succeeding Mr. Ford. Mr. McCosh joined National Carbon in 1939. Following several assignments in industrial sales, he was named manager of the Central Division of carbon products sales, with headquarters in Chicago in 1954. In 1956 he was made manager of railroad and industrial brush sales in New York, and since 1960 he has served as manager of carbon products in the marketing organization.

Edward G. Kondas has been named general superintendent of Republic Steel Corp.'s Chicago, Ill., district steel plant. He succeeds **A. A. Kappenhagen,** who was promoted and transferred to Republic's Warren, Ohio, steel district as assistant district manager. Mr. Kondas has been associated with Republic since 1948 and has been assistant superintendent of the Open Hearth Department at the company's Cleveland, Ohio, district steel plant since 1954. Upon joining the company, he participated in the Technical Operating Training program and upon completion of the program in 1950, was appointed charging foreman in the Cleveland plant's Open Hearth Department. He was named general charging foreman of the department in 1953.

Carl E. Anderson has been elected president and chief executive officer of E. W. Bliss Co. Mr. Anderson was also elected to the board of directors of the company. **Robert Potter,** chairman of the board of directors, has been serving as acting president. Mr. Anderson was previously the director of general management consultation for Ebasco Services, Inc.

Gordon C. Campbell has been promoted to chief industrial engineer, Alan Wood Steel Co. Previously, he held the position of assistant chief industrial engineer.

Eugene R. Mackey has been appointed superintendent of the coke plant at Republic Steel Corp.'s South Chicago steel plant. He succeeds **Henry F. Kelley,** who retired June 30, after more than 37 years with Republic in Chicago and Warren, Ohio. Mr. Mackey has been assistant superintendent of the coke plant since 1957. He joined the company in 1943 as turn foreman of the coke plant shortly after its completion. Prior to joining Republic, he had been employed by The Youngstown Sheet and Tube Co. at South Chicago, and earlier, at Campbell, Ohio. **Raymond C. Gardner** succeeds Mr. Mackey as assistant superintendent of the coke plant. With Republic since 1943, Mr. Gardner has been general foreman of the coke plant since February this year. He began his Republic career at the Chicago plant as an operator in the by-product plant and was named foreman in 1947. In 1957, he was appointed turn foreman of the coke plant.

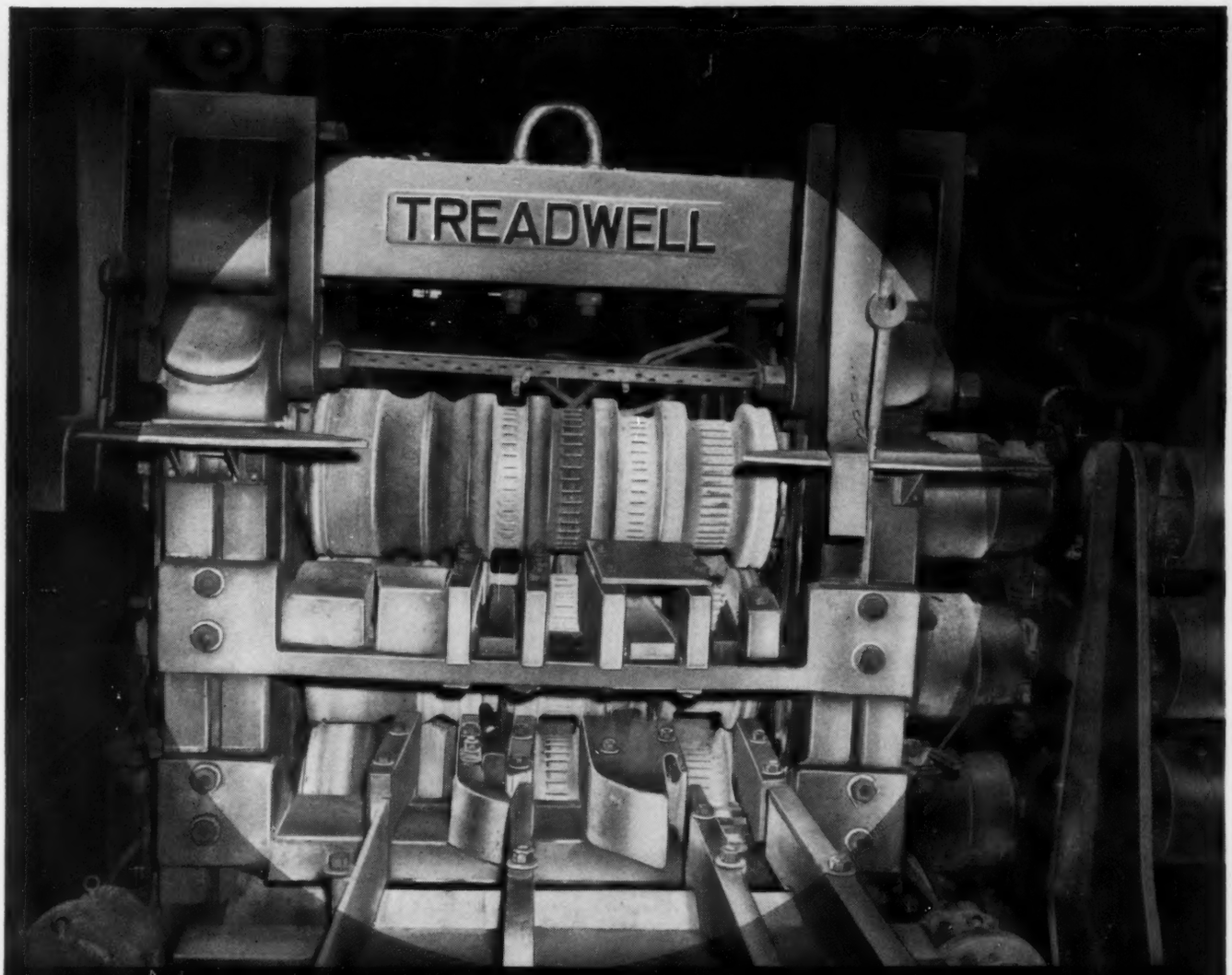
Townsell G. Marshall has been appointed manager of contract administration, Armco Steel Corp. **J. Edward Maddox** will succeed Mr. Marshall as assistant to the manager of the Ashland, Ky., works of the company's Armco Division. Mr. Marshall began working at the Ashland plant in 1937. He carried out a variety of assignments in industrial engineering and personnel work and was named assistant to the manager of the Ashland works in 1957. Mr. Maddox started his Armco career at the Ashland plant in 1941. He was appointed an industrial engineer in 1955 and a senior industrial engineer in 1957. Later that year he became supervisor of labor relations, the position he held until his recent promotion.

David E. Poole has been appointed chief engineer of Republic Steel Corp. Southern District, Gadsden, Ala. Mr. Poole comes to Gadsden from Warren, Ohio, where he was project engineer on the new 56-in. hot strip mill. He joined Republic in 1947 as a draftsman-designer, later working as a mechanical engineer before being assigned to the installation of the hot strip mill.

Peter M. Dereski was appointed superintendent of Republic Steel Corp.'s Troy, N. Y., blast furnace. Mr. Dereski succeeds the late **C. M. Adams.** He was general foreman of the Troy furnace for 18 years prior to his appointment as superintendent and was turn

D. E. POOLE

P. M. DERESKI



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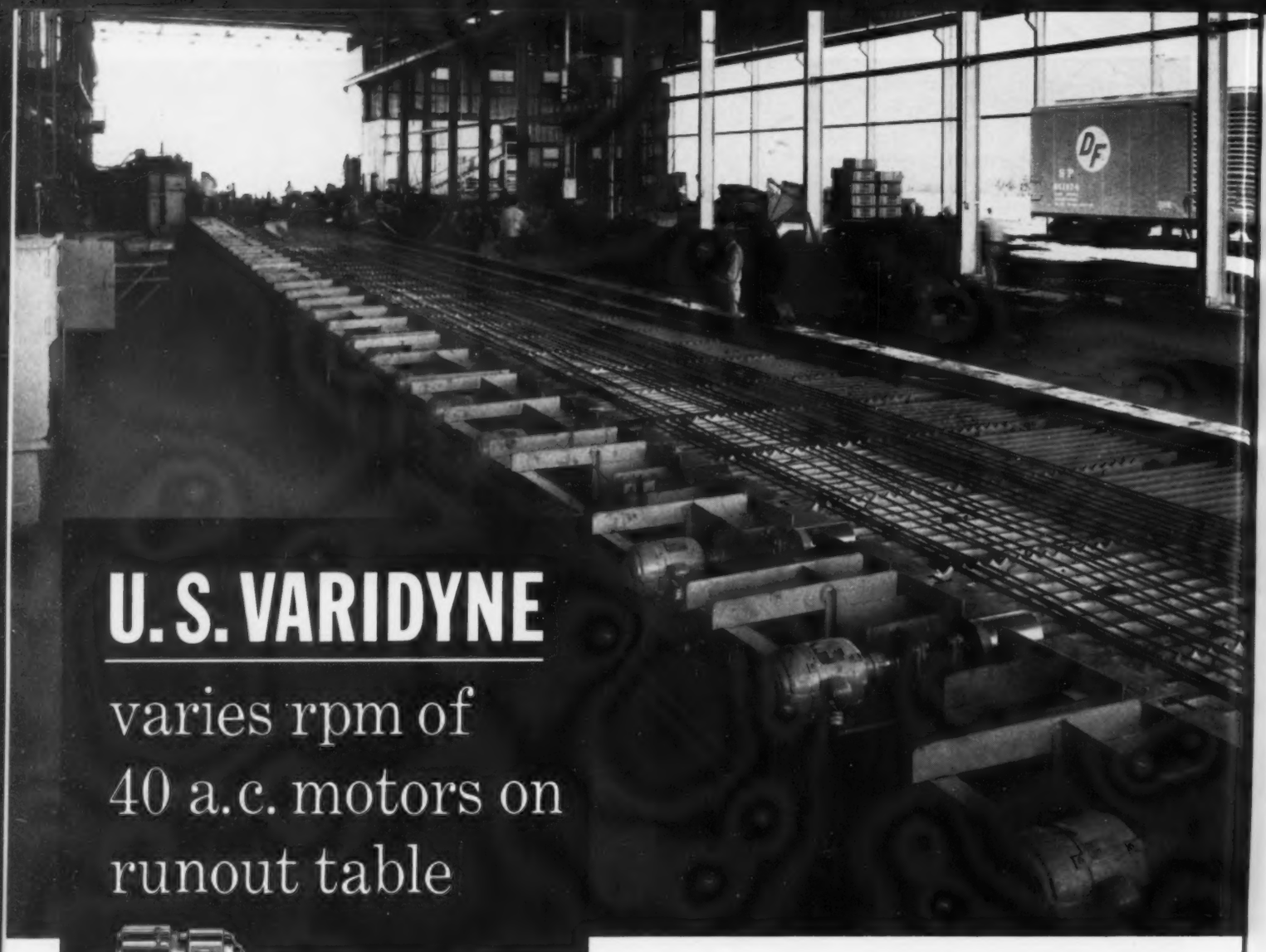
STEEL MILL EQUIPMENT

Manipulators, Mill, etc.	Tables, Mill	Drivers & Pinions	Bumpers, Furnace
Mills, Billet, Merchant & Bar	Tables, Tilting & Lift	Ejectors, Furnace	Pushers, Furnace
Mills, Rod	Tables, Transfer	Gauges, Shear, Saw, etc.	Handling Equipment
Mills, Vertical Edging	Transfers	Beds, Cooling	(Kick-offs, Piers,
Mill Repeaters	Conveyors, Coil	Beds, Inspection	Cradles, etc.)
Coilers & Reels			

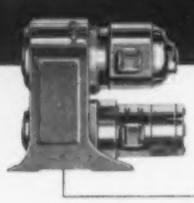
SPECIAL MACHINERY

CASTINGS—Electric Furnace Steel, Ductile Iron, Gray Iron and Ni-Hard



U.S. VARIDYNE

varies rpm of 40 a.c. motors on runout table



PROBLEM: A steel rolling mill's runout table, 128 feet long, required variable speeds for varied cooling requirements, plus the coordination of 40 totally-enclosed motors.

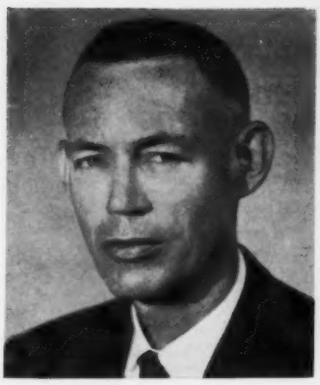
SOLUTION: U. S. VARIDYNE a/c Drive System not only provided the required variable speeds and coordination, but permitted the use of rugged totally-enclosed *a.c.* motors.

Working with the mill's engineers, U. S. MOTORS field engineers selected the optimum U. S. Varidyne system. Varidyne was chosen over a d.c. system because rugged, simple a.c. equipment minimizes maintenance and provides the reliable heavy-duty power required in a rolling mill. By supplying a.c. current in varying frequencies, VARIDYNE varies motor speeds in direct proportion to frequencies . . . motors are automatically coordinated. Varidyne systems are supplied for a wide variety of industrial drive applications, such as conveyors, machine tools, processing equipment, and web systems.

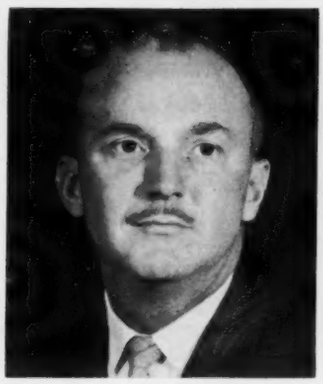
U.S. ELECTRICAL MOTORS INC.

P. O. Box 2058 • Los Angeles 54, California—or Milford, Connecticut

FREE BROCHURE
...send for No. F-1963



L. S. MOBLEY



W. H. GEARY

C. R. LONGWELL

D. D. MacPHERSON

foreman with Troy Furnace Corp., previous owners of the furnace, from 1934 to 1940. Mr. Dereski has been succeeded as general foreman by **Lloyd E. Schuster,** formerly assistant to the superintendent.

L. S. Mobley has joined the New Product Development Department of Dravo Corp., as a development engineer. Mr. Mobley, was chief engineer, Southern District, for Republic Steel Corp. in Gadsden, Ala., from 1955 until May of this year.

Warren H. Geary has been appointed executive vice president of Ritter Engineering Co. Mr. Geary has been associated with Ritter Engineering since 1952.

C. Reid Longwell was appointed special representative in the Metal Processing Division, the Brooks Oil Co. He will be assigned to the executive offices in Cleveland, Ohio.

Dudley D. MacPherson has been elected president of the R. T. Patterson Co., Inc. He succeeds **R. T. Patterson** who has been elevated to the post of chairman of the board and chief executive officer.

Willard Roth has been appointed engineering manager for Sunbeam Equipment Corp. He was formerly assistant chief engineer.

Jerome H. Fuchs has been named executive assistant to the president, Rockbestos Wire & Cable Co., Division of Cerro Corp. Mr. Fuchs previously headed his own management consulting firm.

NEW NEW NEW NEW NEW NEW NEW NEW NEW

when it

MELTS

you know the *temperature!*

NEW *Markal*

THERMOMELT

TEMPERATURE INDICATORS

With Handy Adjustable Holder

The easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

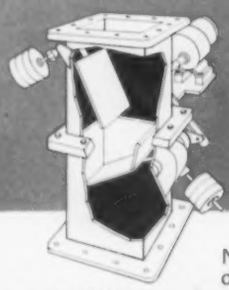
A Stik For Every Temperature from 113° F. to 2000° F.

SEND TODAY for free THERMOMELT literature and pellet sample (indicate temperature desired).

ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

Made by the Manufacturers of Markal Paintstik Markers and Protective Coatings.

MARKAL CO. 3087 West Carroll Avenue • Chicago 12, Illinois



WP DUST VALVES

last longer . . . work efficiently . . . at temperatures to 750° F!

Neither mechanical abuse nor heat distortion can affect sealing efficiency of Western Precipitation dust valves. Why? Unique design . . . superior engineering . . . rugged cast and machined construction.

R-1 MOTORIZED TIPPING VALVE with WP "flap" closures (shown) is used in Positive Pressure Installations up to 20" VWC; Negative to 30" VWC; especially where dust is too light to operate Gravity-Operated model.

GRAVITY-OPERATED TIPPING VALVE is ideal for sealing negative pressure dust collector hoppers handling dry, free-flowing material, and not requiring positive time-cycle operation.

FLOATING SEAL VALVE is the only "revolving door" type valve. Replaces soft wiper materials with a carefully-machined cast iron "Floating Seal" of controlled hardness for 750° F. operation.

WANT DETAILS? For literature, write Western Precipitation, 1000 W. 9th St., Los Angeles 54, California. (In Canada, write 8285 Mountain Sights Ave., Montreal, P.Q.)

WESTERN PRECIPITATION

DIVISION OF JOY MANUFACTURING COMPANY

Earll R. Muddiman retired recently from United States Steel Corp. At the time of his retirement he was assistant to the chief engineer, Fairless works. Mr. Muddiman started with United States Steel in 1923.

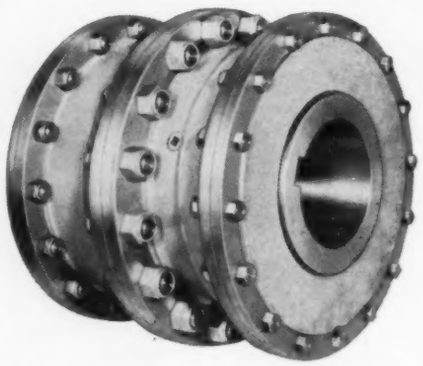
M. L. Watson has been appointed midwestern district manager for Planet Corp. Previously, Mr. Watson held a similar position with Palmer Bee Co.

A. J. Hornfeck has been appointed director of research, Bailey Meter Co. At the same time, **J. E. McEvoy** was named manager of the Product Engineering Department; **R. E. Clark,** manager of the Equipment Engineering Department; **J. K. Loeser,** manager of the Project Engineering Department; and **J. V. Werme,** manager of the Electrical Engineering Department.

Thomas F. Scannell has been named vice president—director of international operations, The Falk Corp. **Don K. Lambert,** who was manager of export sales, will be director of international sales.

Obituary

Dr. Anson Hayes, former vice president in charge of research for Armco Steel Corp., died July 25. Dr. Hayes joined Armco as chief chemist in 1928. He became director of research in 1929, and held that post until 1946, when he was elected a vice president. The following year he became a consultant to the company.



Heavy duty gear type

up to 6,000 hp per 100 rpm

Here's the coupling with all the muscle you need for heavy duty slow speed mill drives. The machined surfaces of each high grade steel casting are given a fine tool finish within strict tolerances. Waldron mill type couplings are easy to assemble, and seal tight against dust, moisture, and loss of lubricant. Standard sizes, 7" to 12". Horsepower per 100 rpm, 1,282 to 6,000. Maximum rpm, 1,950 to 1,200. Write for Bulletin S-1050 to Waldron-Hartig, a division of Midland-Ross Corporation, Box 791, New Brunswick, N. J. MR

WALDRON Makes it easy to pick the right Couplings

Another Installation in Pittsburgh Steel Co. Plant at Monessen, Pa.

HOT METAL MIXER UNDER CONSTRUCTION

The Brief Case of a Hot Metal Mixer LINED WITH RAMTITE®

—That was Subjected to 750,000 *TONS* of Molten Steel

- AREAS—Furnace completely lined with 90-RAM plastic refractory and No. 25 RAMTITE except for roof, upper sidewalls above metal line and the bottom invert. The materials were rammed. RAMTITE anchors and castings were also used.
- These RAMTITE products were exposed to 750,000 TONS of processed metal.
- Service life was excellent by comparison to previous results. Repairs were not necessary until 21 months after installation. (At the end of one year, the pour-in areas were repaired.)
- *Installation technique, quantities of materials used, thicknesses applied and other details supplied on request.*

28 Hot Metal Mixers Now Resurfaced With 90-RAM!

"THERE'S A RAMTITE PRODUCT FOR EVERY REFRACTORY USER"

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.
1813 South Rockwell St., Chicago 8, Ill.

THE RAMTITE CO., DIV. of the S. Obermayer Co.
1813 South Rockwell Street, Chicago 8, Illinois
Please send:
☐ Further information on Resurfacing Hot Metal Mixers
☐ General Information about RAMTITE. May be particularly interested in your refractories for_____
☐ Representative (without obligation)
Company Name_____
Attn. Mr._____ Title_____
Address_____
City_____ Zone____ State_____

Injection tuyeres contribute to improved blast-furnace performance

NBD reports on tuyere designs that simplify gas injection

Extensive research by iron producers the world over has firmly established the benefits of fuel and steam injection: higher blast temperatures, reduced coke requirements, increased tonnage and lower iron costs. And the tuyere, for decades a vital part of the blast furnace, is now assuming the additional function of an injection device.

Cooperating with blast-furnace operators, NBD product engineers are contributing to successful, simplified injection practices. An example is the sectioned tuyere pictured here which offers these distinct advantages:

1. The injection-tube feature may be incorporated in the basic tuyere design used in any furnace, whether the tuyere is a Standard, Angle Flow, Weir, Tennessee, or other design.

2. It serves a dual purpose in that it may be used in all tuyere locations in the furnace—and operated at will, with or without gas injection. Tuyere inventories are held to a minimum.

3. No expensive special equipment, such as lances or redesigned blow pipes and coolers, is required—just simple piping.

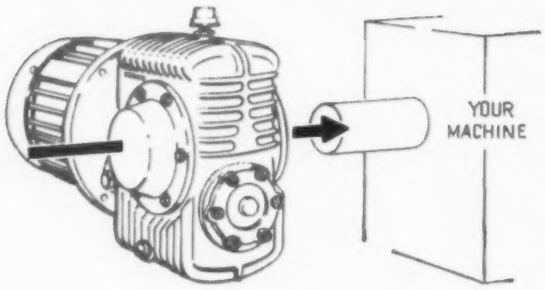
4. No exposed lances, nozzles or pipes, subject to damage by slag or metal splash.

An NBD sales engineer is prepared to give you more information specific to your application. Call him or write us.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
717-O Grant Building • Pittsburgh 19, Pennsylvania
PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PENNA.

CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

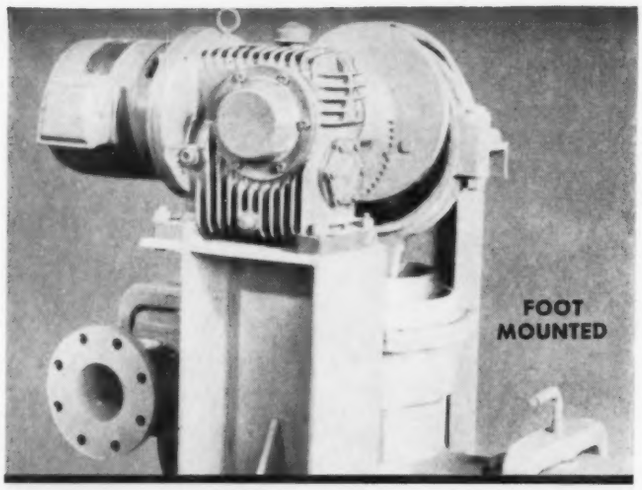
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

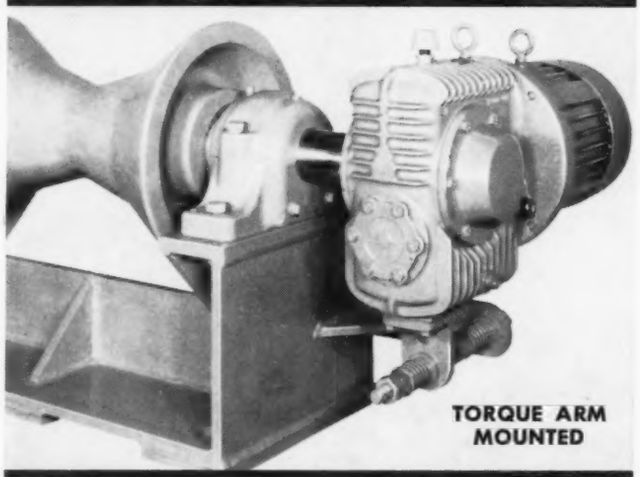
Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS





HOW TO HOLD A CUP OF HELLFIRE

Gently, friend. We're pouring a cup of molten iron from a man-made volcano. No slips twixt cup and lip, please. And now the pouring ladle must be moved to the mold and its contents emptied. A touchy problem in material handling? Yes, a delicate problem. Yet this is the daily activity of foundries and mills throughout America—the daily work of Whiting cranes and materials handling systems.

If you have to move materials—in shop or mill, dock or warehouse—move it at low cost, dependably and safely, call on Whiting. There are specialists here who can talk your language.

The facts on "How to Select an Overhead Traveling Crane" are yours for the asking. Ask for Bulletin 79. Write *Whiting Corporation*, 15655 *Lathrop Ave., Harvey, Illinois.* In Canada: *Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada.*

See our catalog in Sweets

90 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

CRANES

WHITING®

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES®; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL PROCESSING EQUIPMENT

Three great names in couplings

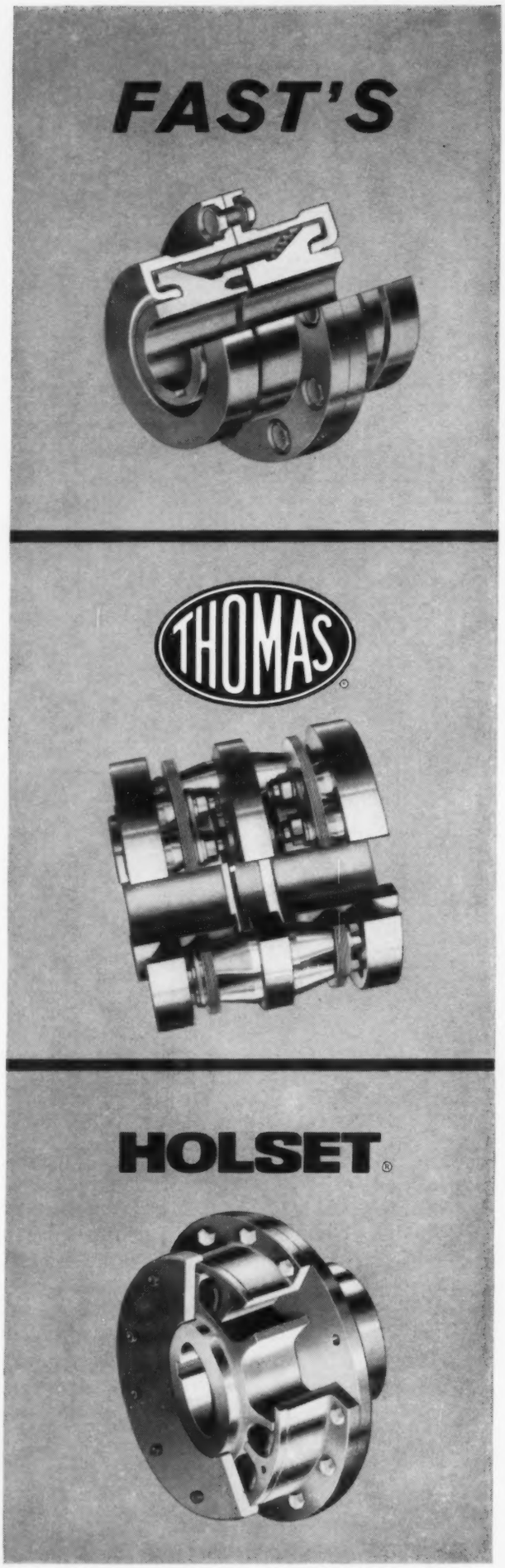
NOW CARRY THIS CORPORATE SYMBOL

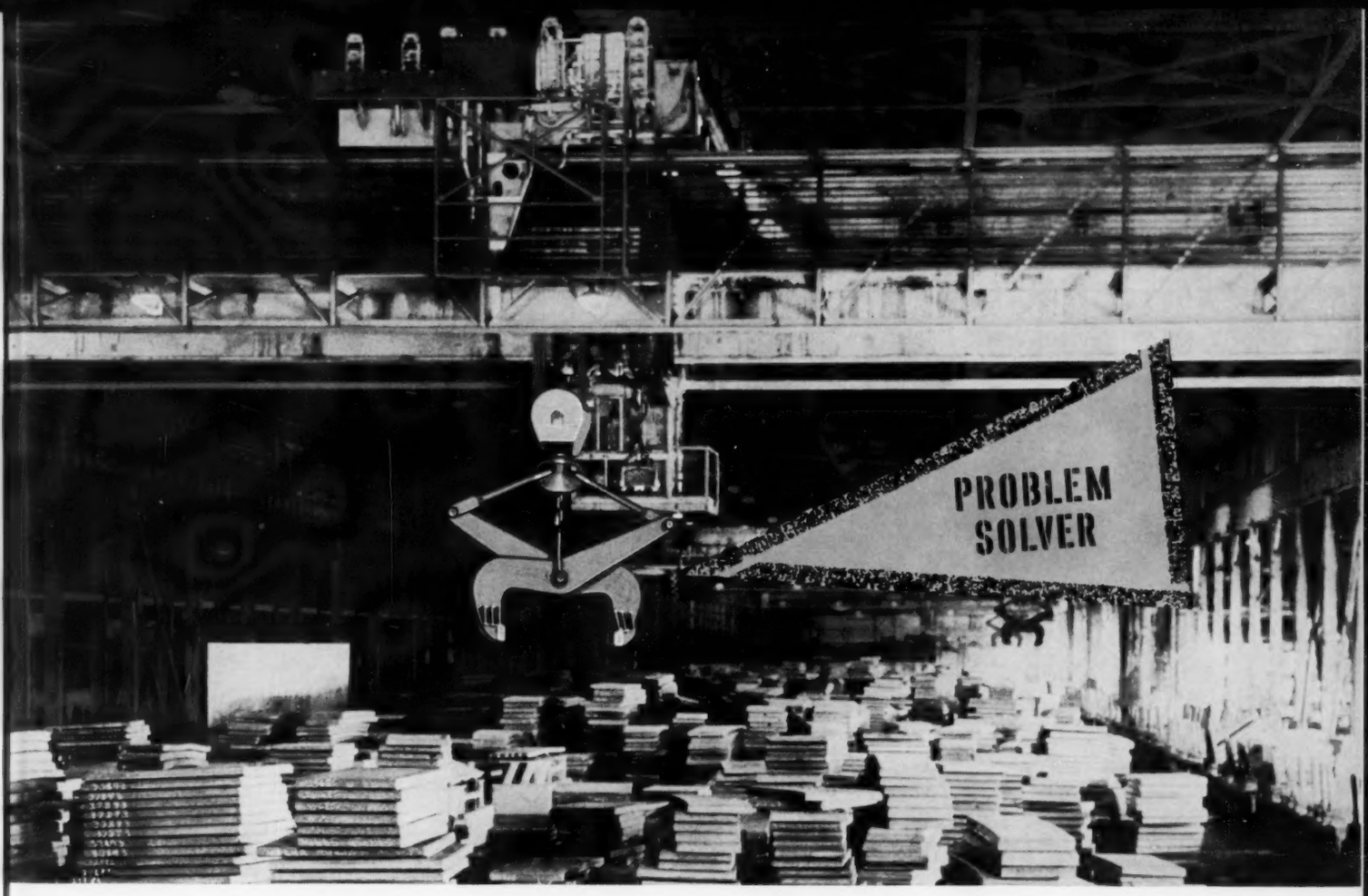
KOPPERS®

With the acquisition of the Thomas Flexible Disc Coupling line, Koppers now provides engineering solutions to a wide range of industrial coupling problems. Need a lubricated gear-type coupling for transmitting high loads? Koppers world-famous Fast's coupling line does the job on shafts up to 32 inches. Need a maintenance-free flexible-disc coupling with no backlash? The highly engineered Thomas line holds the answer—with miniature couplings as small as 1/12th of an ounce. Need a coupling to absorb impact or vibration? The Holset line of resilient, non-lubricated couplings protects equipment in most diesel, compressor and shock load applications.

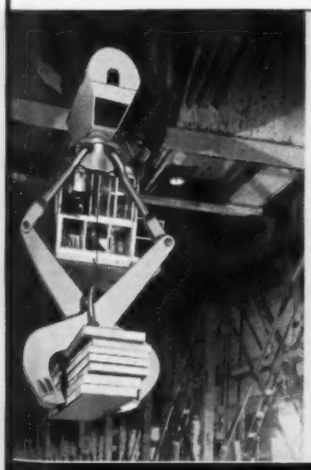
Because each of these coupling lines has its particular application in industry . . . and because each is a recognized name in the power transmission field . . . you can continue to buy them by brand—just as you have in the past. Of considerable importance are the experienced, extensive engineering and manufacturing services of the entire Koppers organization that are available to help you with your power transmission problems . . . in any size, in any quantity, for any use.

KOPPERS COMPANY, INC.
COUPLING DEPARTMENT
Baltimore, Md. • Warren, Pa.
Engineered Products Sold with Service

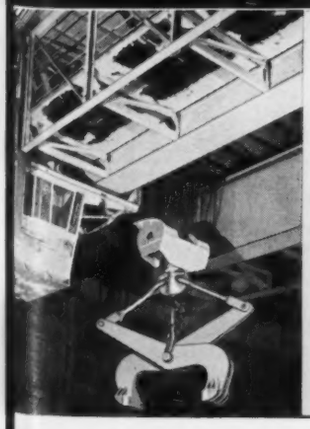




TONGS put a tight grip on safety and economy



The tong jaws open to 76½ inches. They are operated by a separate hoisting unit with cable connected to the pivot point of the tongs.



The cab on these cranes is air-conditioned for operator comfort. It is supported from and travels with the trolley overhanging the rear girder.

Inland Steel Company gave up chains, spacers, and "hooker" manpower in piling slabs in No. 2 Slab Yard at East Chicago, Ind. Time proved the method unsafe for both "hooker" and crane, and inefficient as well. The chains often hung-up and had to be pulled free by the crane operator. Haphazard piling also robbed the yard of storage space.

Inland Steel's plant engineers and Shaw-Box engineers solved the problem. Now five "Shaw-Box" Cranes with unique tongs handle an average of 60,000 tons of slabs a week. They are 120-foot span cranes with 50 and 25 ton hooks, each with a lifting speed of 40 FPM. All slab piling is handled from the cab which travels with the trolley. Slabs are piled far neater than before, and many more can be stored in the same area.

Since their erection in 1957, all five cranes have proved their quality in dependable service. The same creative engineering has made great problem solvers of all types of Shaw-Box Cranes, whether built to AISE specs or individual standards of construction and performance. We welcome the opportunity to serve you.

MAXWELL MANNING & MOORE INC. TRADE MARK
60 K-1

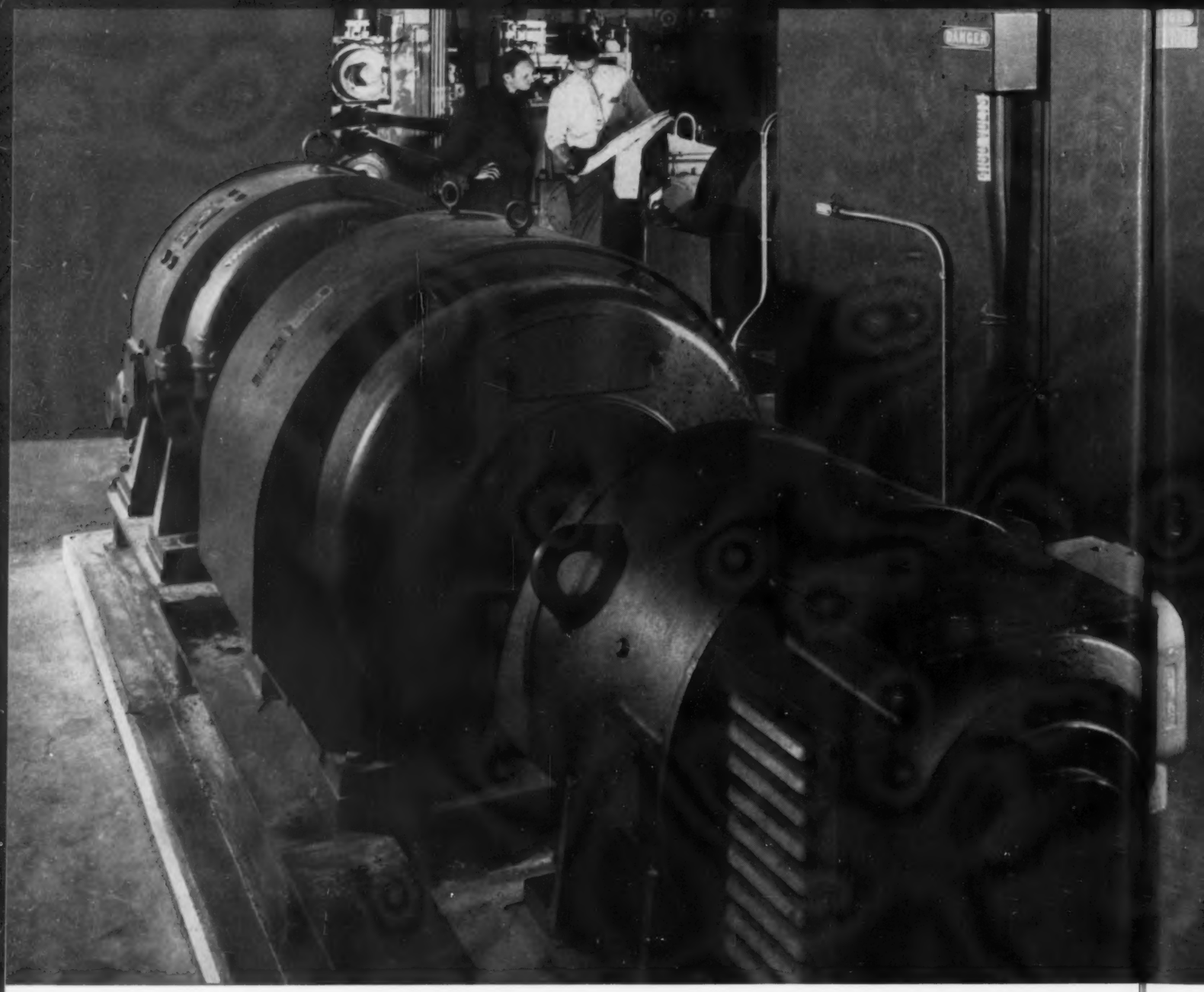
SHAW-BOX® CRANES

A product of

MANNING, MAXWELL & MOORE, INC.

ELECTRIC OVERHEAD CRANE INSTITUTE E.O.C.I. MEMBER

Shaw-Box Crane & Hoist Division • Muskegon, Michigan
In Canada: Manning, Maxwell & Moore, Ltd., Galt, Ontario



RELIANCE SYSTEMS ENGINEERS SOLVED THE PROBLEM BEFORE THE ANSWER WAS BUILT

It works precisely, as they said it would.

What you see is the source of D-c. power for a dual-purpose cold mill . . . Reliance motors, generators and mill controls. What you don't see, but what the customer gets, is extreme accuracy and smooth, economical operation, from Reliance Systems Engineering.

The cold mill itself uses four rolls for cold reducing . . . two rolls for tempering and finishing. A 250 hp. Reliance D-c. motor powers the mill and can be quickly coupled to either set of rolls, depending on the operation selected. Utilization of full motor speed range produces a maximum of 300 feet per minute on 8″ or 20″ rolls. The reel is driven by a 100 hp. D-c. motor with two VSR regulators, one to match the speed of the mill—the other to maintain tension. Reliance Engineers determined the *right* regulators to use and *how* to use them, saving this customer equipment and operating costs.

Reliance Systems Engineers can apply their talents to your systems operations—in advance—give you the thinking and the products that do the job you want and need. Can we help you?

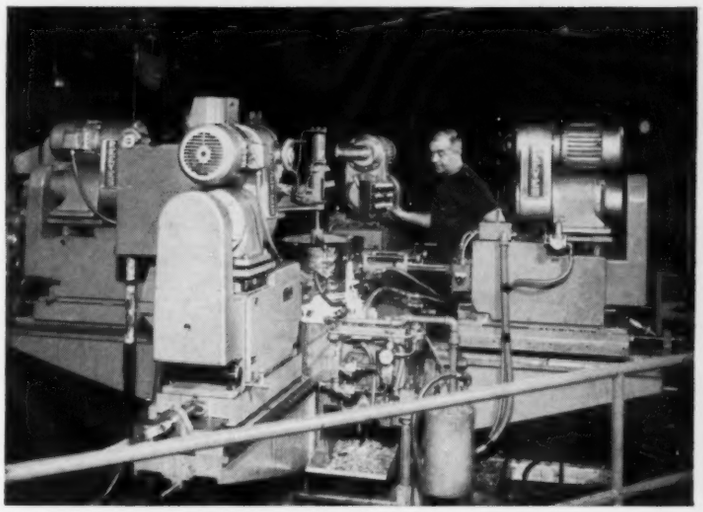
BUILDERS OF THE TOOLS OF AUTOMATION

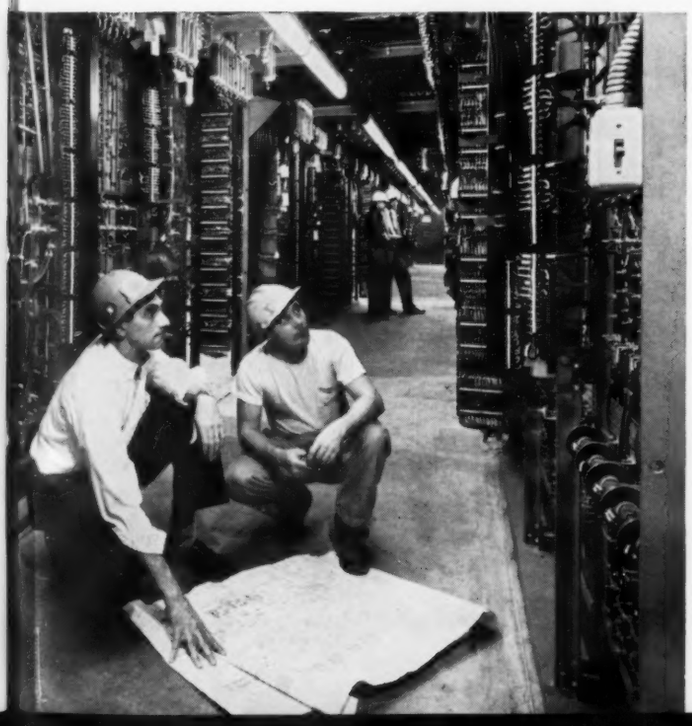
A-1682

ONE SELF-CONTAINED, COMPACT POWER PACKAGE. This MASTER GEARMOTOR has been operating outdoors for 5 years regardless of weather. It has no exposed high speed couplings, no V-belts, chains or sprockets. Engineering and assembly costs are reduced. You can simplify installations and save space with vertical, horizontal and flange mountings; output shaft over, under, left or right. Ratings 1/8 to 125 hp. in right angle, parallel or in combination. Right angle ratios are available up to 96:1; parallel 120:1. Bulletin E-2409.

CONTOUR EPOXY-COATED TO ELIMINATE ENCAPSULATION CRACKING. New RELIANCE ENCAPSULATED MOTOR . . . gives you positive protection from dust, dirt, acid and water. Unlike other heavy molded coatings, stator windings are vacuum-impregnated with epoxy resin at a uniform thickness, follow the contour of the windings. You get maximum flexibility, tensile and bond strength, plus quicker cooling . . . all vital to superior motor performance. Bulletin B-2108.

INFINITELY VARIABLE OUTPUT SPEEDS AT LOW COST. REEVES MOTODRIVES, shown here powering this 4-position drilling and boring machine, are used extensively for hundreds of production needs. Horsepower ratings from ¼ to 40, speeds from 1.71 to 4660 rpm. Speed variation ranges from 2:1 to 10:1. Available in hundreds of space-saving assemblies . . . with manual, remote or automatic process control (Airtrol). Bulletin M-592.



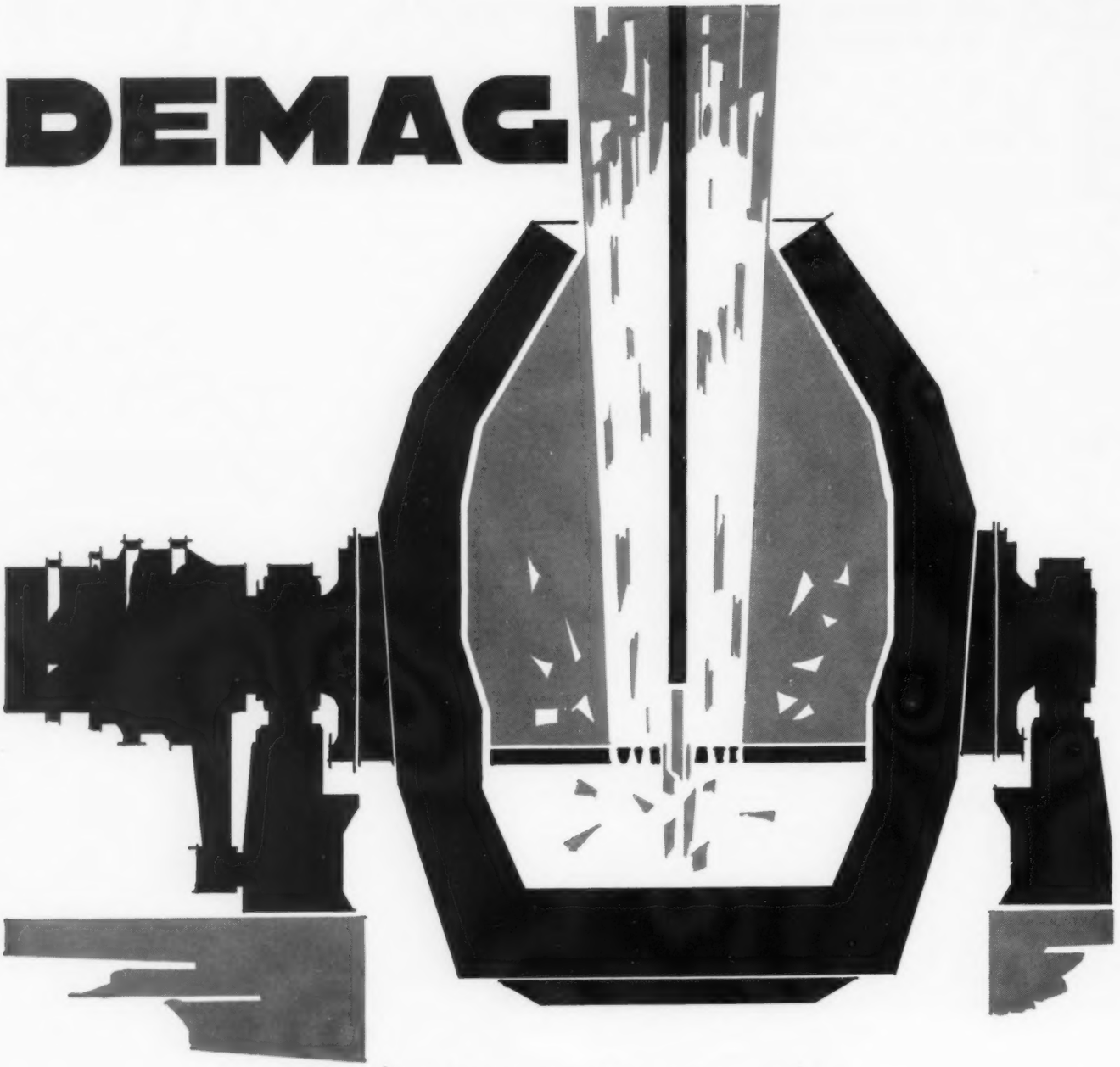


TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 11-9 CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.

DEMAG



Milestones in Oxygen Steelmaking LD

The LD-Process started a revolution in steelmaking. DEMAG has played a leading part in this development, including the building of 5 to 175 metric ton LD furnaces and the design of super LD furnaces from 250 to 300 tons. Further new developments typical of DEMAG's work in oxygen steelmaking include:

LD-AC Furnaces • Rotor Furnaces • Kaldo Furnaces

AMERICAN DEMAG CORPORATION, ONE GATEWAY CENTER, PITTSBURGH 22, PA.

SUBSIDIARY OF:

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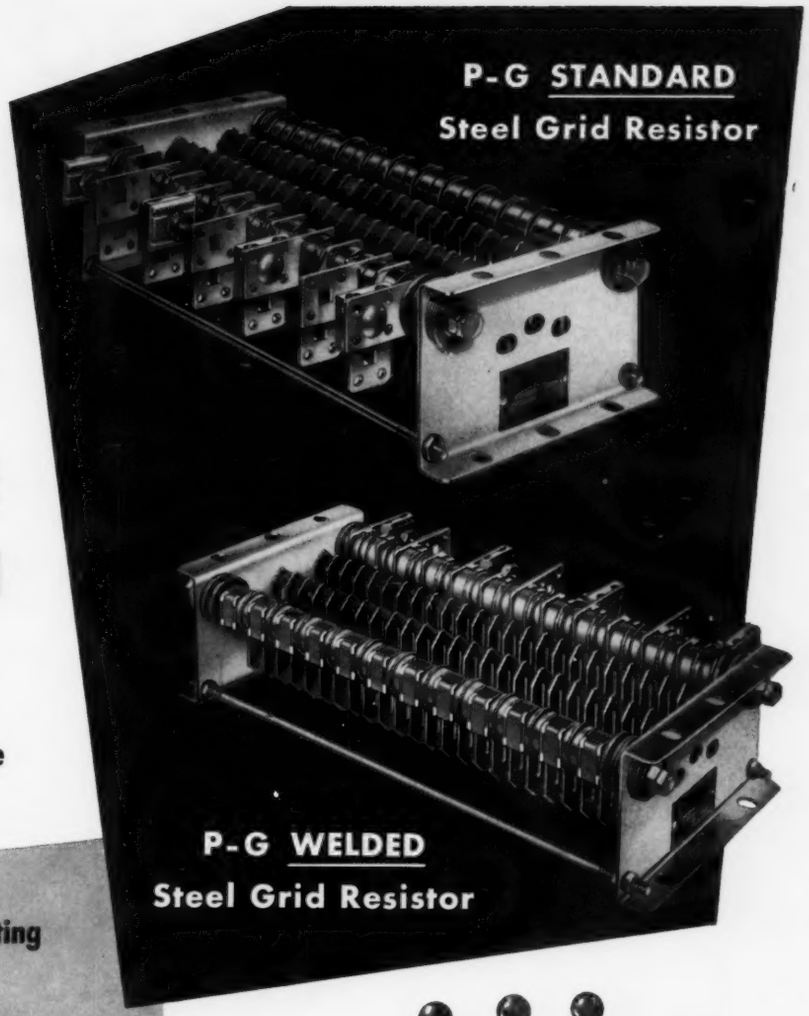
P-G the ORIGINAL

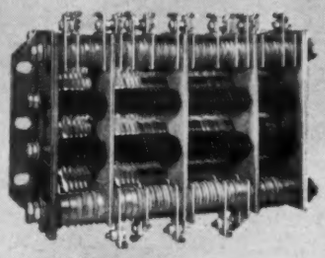
Steel Grid Resistor

plays an essential part in the production of steel

Built for severe service conditions
Protects vital electrical equipment
Constant "trouble free" performance
Quick adjustments easily made

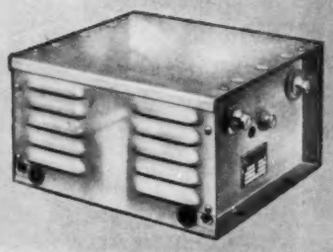


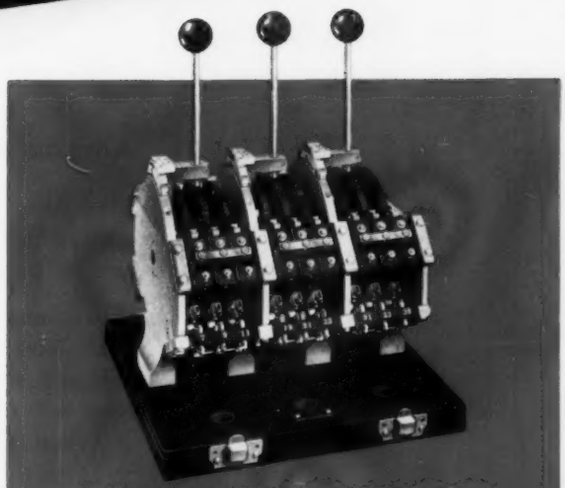
P-G Resistors for Internal Mounting in Face Plate Controllers



Standard Units for 2 to 25 H. P. Motors. Also supplied for external mounting.

P-G Resistors for **SAFETY LIMIT STOPS** Available in standard units for any size motor.





P-G Type MD **Master Switch**

for general application in Mill Service

Save valuable mounting space . . . One to four switches in a single enclosure . . . Overall length less than 22" on four-unit Switch.

Send for Bulletins

P-G

ESTABLISHED 1892

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky

MAILING ADDRESS—Box 709, Covington, Kentucky

HOW LONG SHOULD A CAMPAIGN LAST?

Amsco stretches furnace campaigns to the limits

Blast furnace campaigns should last to the limits of lining life. But premature failure of furnace bells causes shutdowns for replacement and loss of production.

Amsco Manganese Steel bells take the abuse of tons of limestone, coke, iron ore, sinter, concentrate or pellets while continuing to seat properly. For example, one steel mill used a small Amsco Manganese Steel bell over 6½ years. Over 1,575,000 tons of material passed over it. When removed its original thickness of 2¼ inches had been reduced to ¼ inch.

Other users have standardized on Amsco Manganese Steel for skip car wheels, car liners, skip bridge rails, bell rod shields, bell seats and receiving hopper wear plates. All of these important parts have helped stretch the campaign to the limits of liner life.

If your campaigns are coming to premature ends due to failure of important wear points, bring your problems to Amsco. We can show you how Amsco Manganese and Alloy Steels can serve you better.

AMERICAN Brake Shoe COMPANY

Other plants in:
Denver • Los Angeles • New Castle, Delaware
Oakland, California • St. Louis
IN CANADA: Joliette Steel and Manitoba Steel Foundry Divisions
IN MEXICO: Amsco Mexicana, S.A.

1561

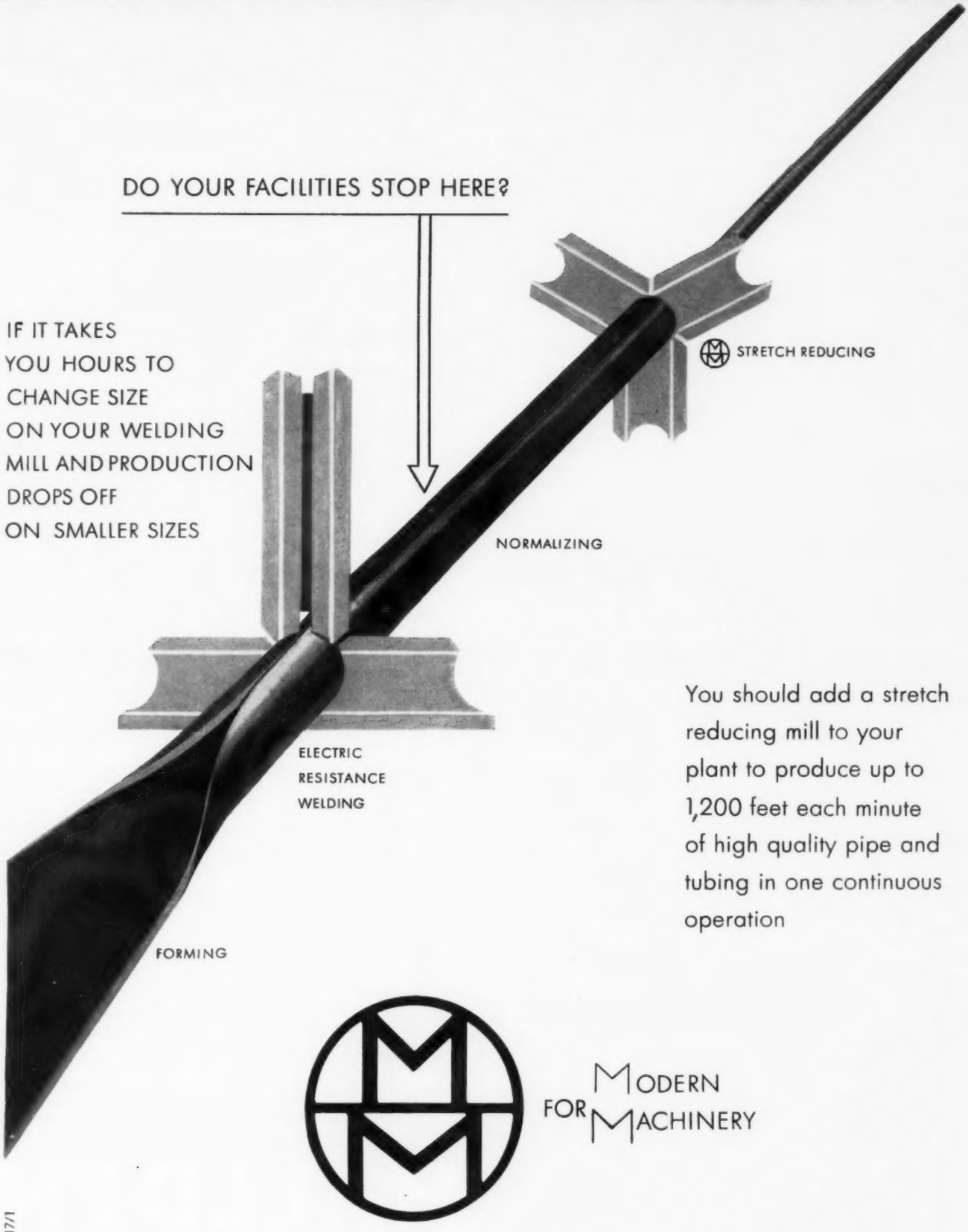
AMSCO

AMERICAN MANGANESE STEEL DIVISION
CHICAGO HEIGHTS, ILLINOIS

A NEW ERA OF PIPE MAKING

DO YOUR FACILITIES STOP HERE?

IF IT TAKES
YOU HOURS TO
CHANGE SIZE
ON YOUR WELDING
MILL AND PRODUCTION
DROPS OFF
ON SMALLER SIZES



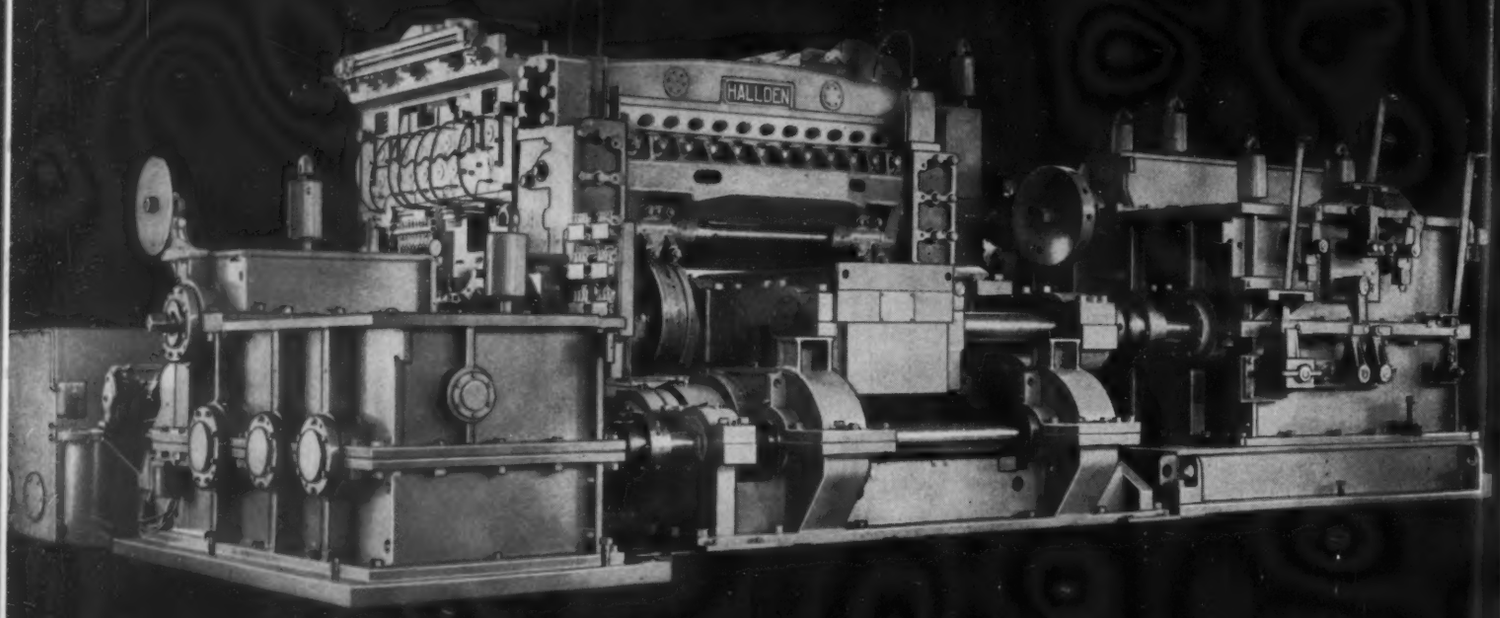
You should add a stretch reducing mill to your plant to produce up to 1,200 feet each minute of high quality pipe and tubing in one continuous operation

MODERN FOR MACHINERY

717/1

FOR FAR-RANGING IDEAS
IN MODERN PIPE MAKING – FOR BETTER,
FASTER, MORE ECONOMICAL PRODUCTION

MANNESMANN-MEER, INC.
755 WICK AVENUE
YOUNGSTOWN · OHIO



SYNCHRONIZED
GUILLOTINE FLYING SHEARS

Specified throughout the world for the most modern high speed processing lines

Hallden Flying Shears are built in a wide range of designs and sizes to meet any strip shearing requirement from tin plate to 5/8" plate. Length of cut ranges from 12 inches up to 48 feet. Synchronization adjustment "on the fly" available. These rugged units have been proven on steel, aluminum and brass strip in cut-up, galvanizing and special process lines for nearly 40 years. For all high production strip shearing consult Hallden, The Shearing Specialists.

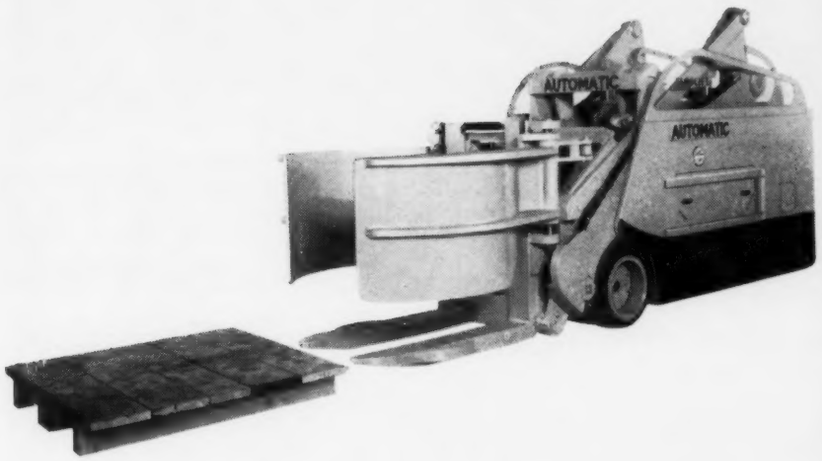
HALLDEN

The world's leading machinery manufacturers rely on Hallden shears in their process lines

THE HALLDEN MACHINE COMPANY • THOMASTON, CONNECTICUT

Associates: The W. H. A. Robertson & Co., Ltd., Bedford, England

Elbolift first picks up pallet.



NEW AUTOMATIC® Mobile Coil Up-Ender

handles tin plate with a feather touch

Now you can handle tin plate more efficiently – without damage to this light gauge material. AUTOMATIC has engineered a unique new attachment for the Elbolift heavy duty truck that up-ends and palletizes coils *anywhere* in the plant. In addition to eliminating damage claims that irritate both your customers and your production people, the truck gives you extra flexibility in your handling operations. The Elbolift can be used for additional handling jobs such as loading coils onto trucks or stacking them into storage three high.

With the up-ender attachment, the Elbolift is available in capacities through 20,000 lbs. Other models available in capacities of 12,000 through 25,000 lbs. Write for up-ender details and for brochure "Heavy Duty Trucks Facts and Factors."

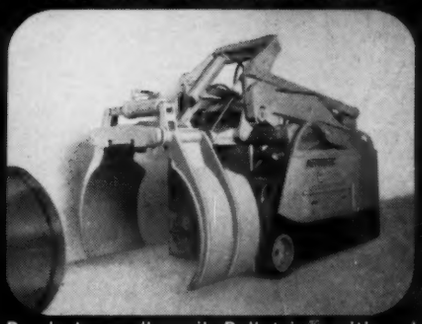
AUTOMATIC

AUTOMATIC TRANSPORTATION COMPANY

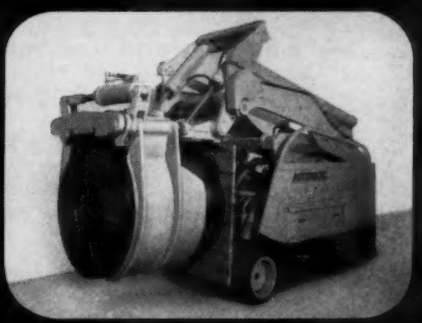
Division of The Yale and Towne Manufacturing Company

47 W. 87th Street, Dept. P1, Chicago 20, Illinois

Pallet is raised and tilted 90° forward. Springs on forks hold pallet in place.

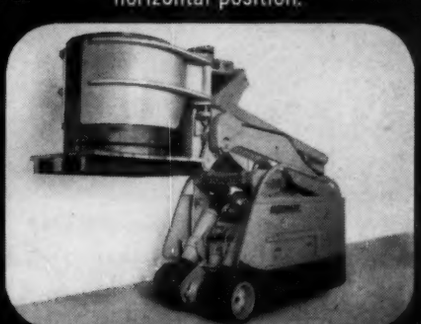


Ready to cradle coil. Pallet is positioned behind coil cradle arms.



Attachment arms with broad bearing surface cradle coil, prevent damage.

Coil with pallet beneath it is rotated to horizontal position.



Ready to strap and load onto flat bed truck or into storage.

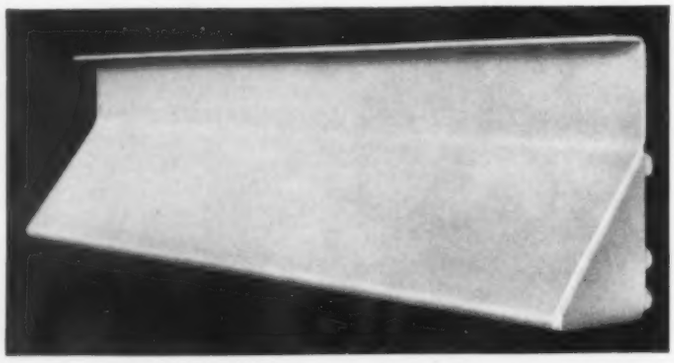
Faster Heats?
Fewer Ladles?
Same Cranes?

Sure it's true . . . and it's guaranteed!
Ask anyone who uses this Sticker Exclusive!

Sticker ▶
Ladle Maintenance
"Safety Cage"

SAFE Stopper and Rod Setting
Immediately After
Pouring Steel

Patented



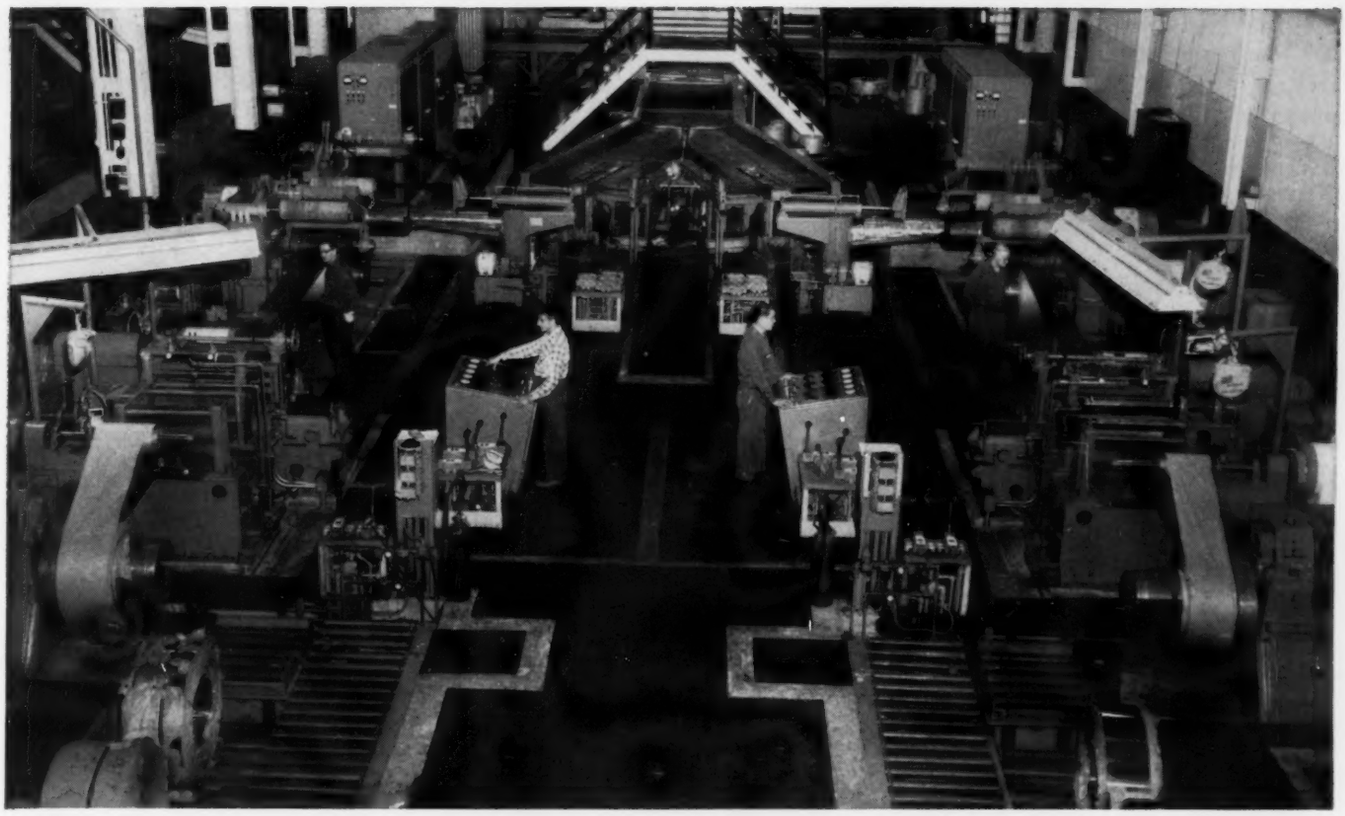
Patents Pending

◀ **"Seamless Face"**
Water-Cooled Skewback Channel
— Another Sticker Exclusive

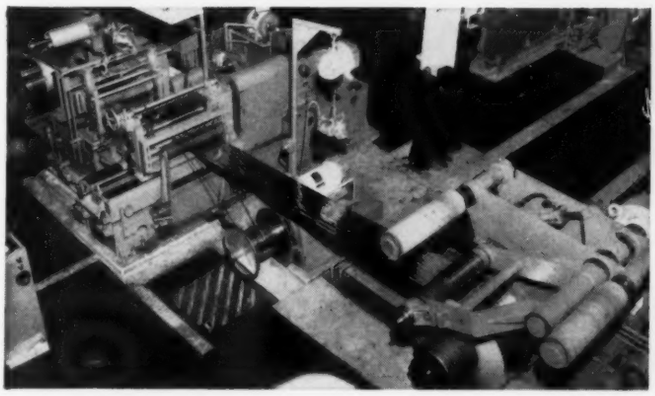
Custom-built to fit your roof contour
Eliminates skew tile
Provides permanent skew face

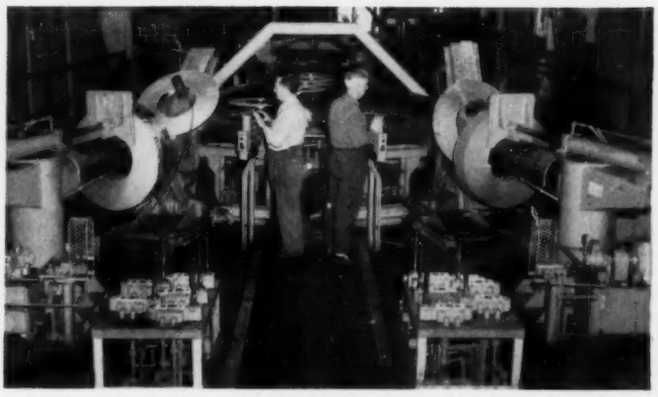
Sticker
STEEL PLANT EQUIPMENT

STICKER INDUSTRIAL SUPPLY CORPORATION
1991 LEE ROAD • CLEVELAND 18, OHIO



Predictable Performance...





SECO Slitting Installation, Superior Steel Division, Copperweld Steel Company, Carnegie, Pa.

is automatic—start to finish—with a SECO *Slitting Line*

SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.

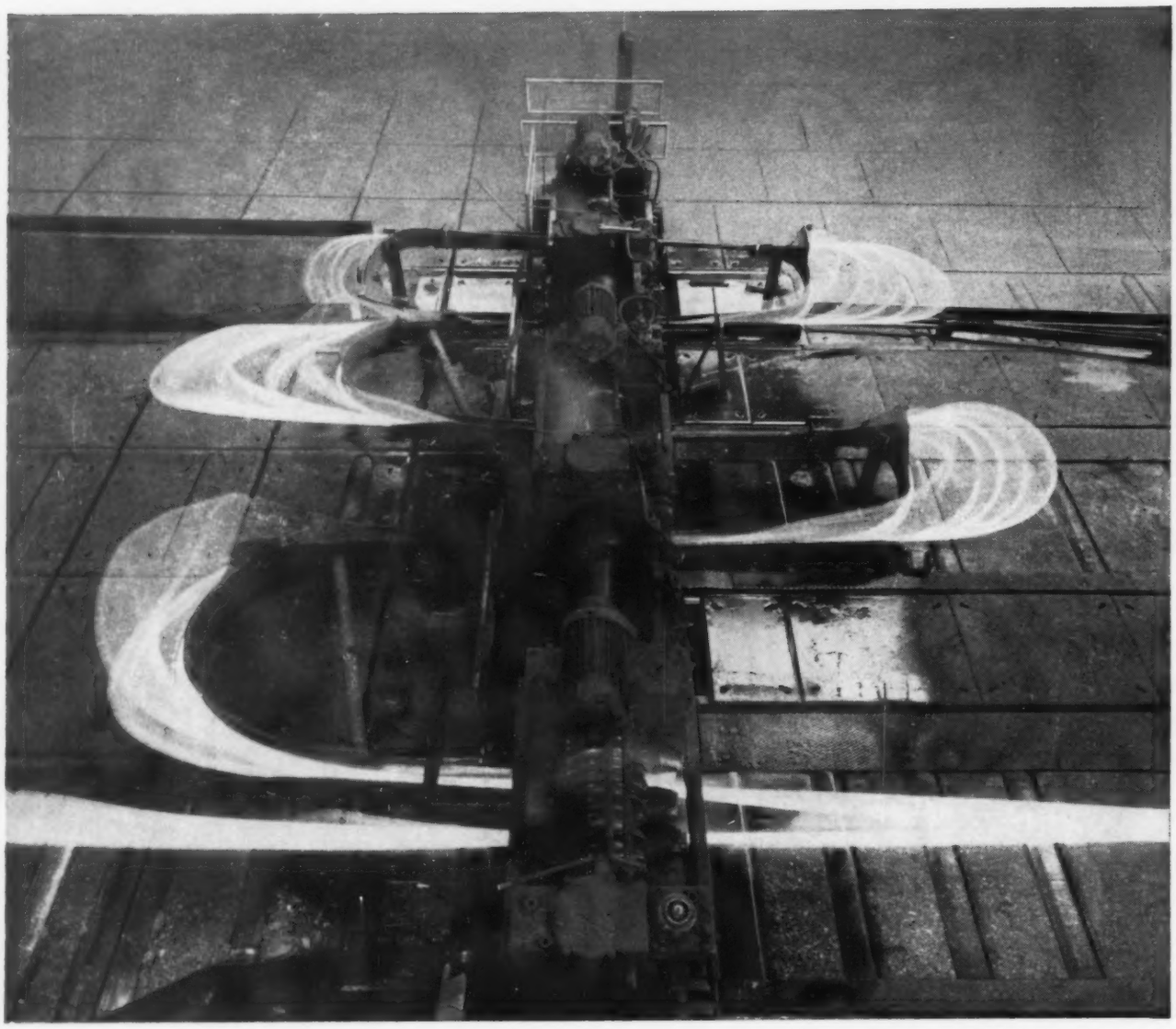
SECO

Every operation in this *complete* slitting line by SECO—from entry to exit of coils—is fully automated. It was specifically designed and built by SECO to meet the maximum performance requirements of the Superior Steel Division, Copperweld Steel Company, Carnegie, Pennsylvania.

SECO's staff of experienced sales engineers, specialists in production problem solving, are prepared to show you how you can get "predictable performance" in *your* operation—whatever your requirements. Call or write today. West Coast representative: United Machine Tool Company, Los Angeles, California.

STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION • CLEVELAND 22, OHIO



Repeater rolling in a 21" train.

Combined Rolling Mill for medium and small sections and wire rod

Morgårdshammar Combined Rolling Mills for high grade steels are designed to give closest possible tolerances and to allow the rolling of a large assortment of dimensions and sections, from 5 in. down to about 3/16 in. round.

For further information, please apply to us for literature.

Swedish Quality

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK. VERKSTADS AB • MORGÅRDSHAMMAR

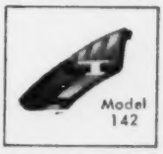
ENGINEERED OIL SEALS for Steel Mills

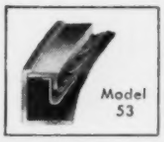
Garlock KLOZURE* Oil Seals (left) help keep lubrication in, dirt out of roll neck bearing at Inland Steel's East Chicago mill.

Inland Steel applies Garlock KLOZURE Oil Seals for protection of mill roll neck bearings at East Chicago.

Minimizing lubrication leakage from the inboard and outboard ends of the bearings, Garlock KLOZURE Oil Seals provide more constant service as the rolls change position in a lateral movement during operation. Inland finds, too, that in atmospheres of dirt, scale and spray, KLOZURE Oil Seals help keep foreign particles from entering—and damaging—the bearings.

For good, economical bearing protection, Inland joins the growing list of steel producers who use Garlock KLOZURE Oil Seals. Wherever you look in mills, you'll find a specific type of KLOZURE Oil Seals doing a specific job. Model 142, for instance, helps keep water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 protect bearings on back-up and work rolls. Model 53 is recommended for table rolls at normal and high speeds. Model 23 Split KLOZURE is ideal where equipment cannot be dismantled too easily.





Designed for peak efficiency and durability, Garlock KLOZURE Oil Seals resist oil and grease, are impervious to water, mild acids, alkalies, withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

If you have a particular sealing problem, why not discuss it with your Garlock representative. He's backed by over 70 years of experience in engineering, production and application. Call him at the nearest of the 26 Garlock sales

GARLOCK

offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-181, Garlock Inc., Palmyra, New York.

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Registered Trademark

These 4 Voss Inverted Roller Levelers are in final assembly. Soon they'll be at work in varied applications ranging from galvanized and hot and cold rolled to plate and high yield missile stock. Each of these companies, already a user of Voss Levelers, know they obtain precise area control and equal to or better than stretcher leveler flatness at high production speeds. Let Voss put 30 years of leveling and flattening experience to work for you.

Call or write today! We'll be glad to arrange a demonstration without obligation.

Voss ENGINEERING CO.

7301 Penn Ave. Pittsburgh 8, Pa. Churchill 2-4422

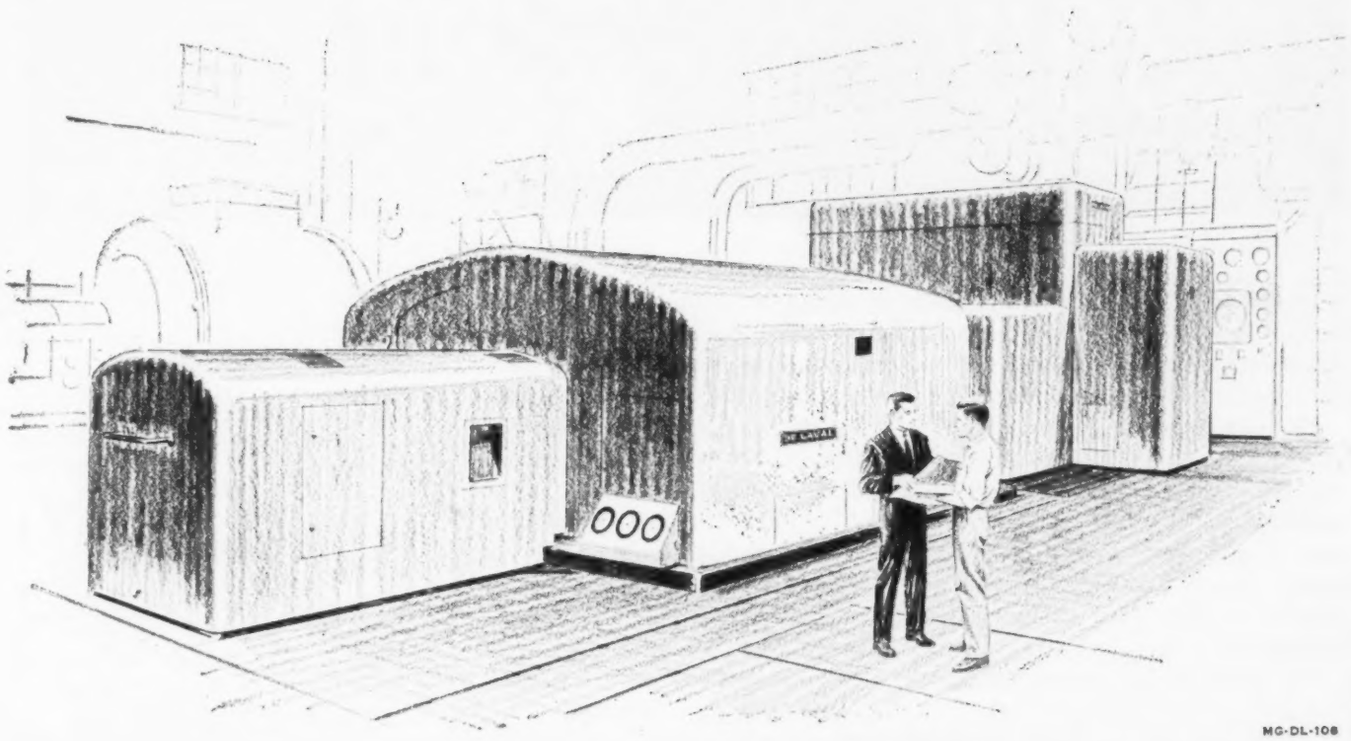
DE LAVAL
engineered
flexibility
lets a turbine "grow"

With his eye on tomorrow, a major food processor gave De Laval unusual requirements. He wanted a turbine that would meet today's power and process steam needs . . . and be capable of almost doubling its output in the future. The result: a De Laval turbine to which five additional stages can be added in the customer's plant.

Present capacity of this unit is 5,000 kilowatts which will be raised to 9,375. For future operations, steam pressure and temperature will also be sharply increased.

Whether you need a turbine that can "grow" or have other problems involving heavy rotating machinery, De Laval engineered flexibility can help.

De Laval Steam Turbine Company, Trenton 2, N. J.



MG-DL-108

DE LAVAL • 60 YEARS OF CREATIVITY AND QUALITY

CENTRIFUGAL PUMPS AND COMPRESSORS • TURBINES • IMO® ROTARY PUMPS AND HYDRAULIC MOTORS
MARINE PROPULSION AND AUXILIARY EQUIPMENT • HELICAL AND EPICYCLIC GEARS • TURBOCHARGERS

SUPERTHERM*

Supertherm offers you outstanding service for applications that require dependable performance at temperatures from 1800 to 2300 F.

Developed by our Research Laboratory in Mahwah, New Jersey, this heat-resistant alloy has done an excellent job under extreme temperatures and severe heat cycling. In many cases it has extended service life two or three times over previous operations.

Supertherm has been cast as furnace rolls, radiant tubes, retorts, grids and other special parts. It is composed of 26% chromium, 35% nickel, and is strengthened and stabilized with cobalt and tungsten.

Our local sales engineers will be happy to answer questions that you may have regarding Supertherm or any high-temperature equipment problems. Or we will be glad to mail you technical data on this heat-resistant alloy, if you will kindly fill in the coupon and return it to us.

Electro-Alloys Division
3039 Taylor Street, Elyria, Ohio

Please send technical data
on SUPERTHERM

Name_____

Title_____

Company_____

Address_____

City_____

Zone____ State_____

Supertherm is a patented alloy.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION · Elyria, Ohio

Equipment News...

HEAVY DUTY TRACK

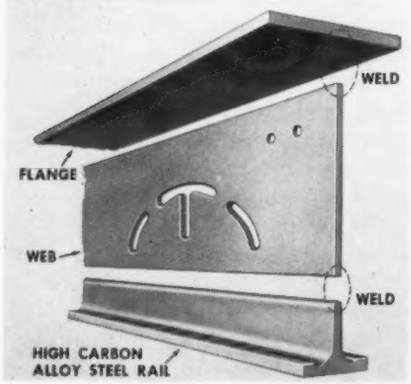
△ Cleveland Tramrail Division of The Cleveland Crane & Engineering Co. has announced the introduction of "Tarca Track," a new heavy-duty track for overhead materials handling service.

The track has been designed to withstand heavy, swinging, jerky loads and provide a smooth trouble-free road for materials movement. It has been engineered to attain maximum strength with minimum weight. Its construction assures extra years of service over ordinary tracks.

The new track is a compound section consisting of a steel flange and web, and an especially rolled high carbon alloy steel rail. These parts are welded continuously from end to end under carefully controlled conditions to form a combined section free of stress concentrations. The parts are carefully proportioned to produce a perfectly balanced design for loads under all conditions.

The rail provides great strength and has a hard, flat, raised tread or running surface. This tread is smooth and becomes highly polished in service, assuring continued easy operation of cranes, carriers and trolleys. The hard, raised-tread surface prevents the rail flanges from peening down, so common with low carbon flat flanges, due to continuous rolling action of the wheels.

Flange, web and rail are joined by welds that are continuous from end to end of the parts.

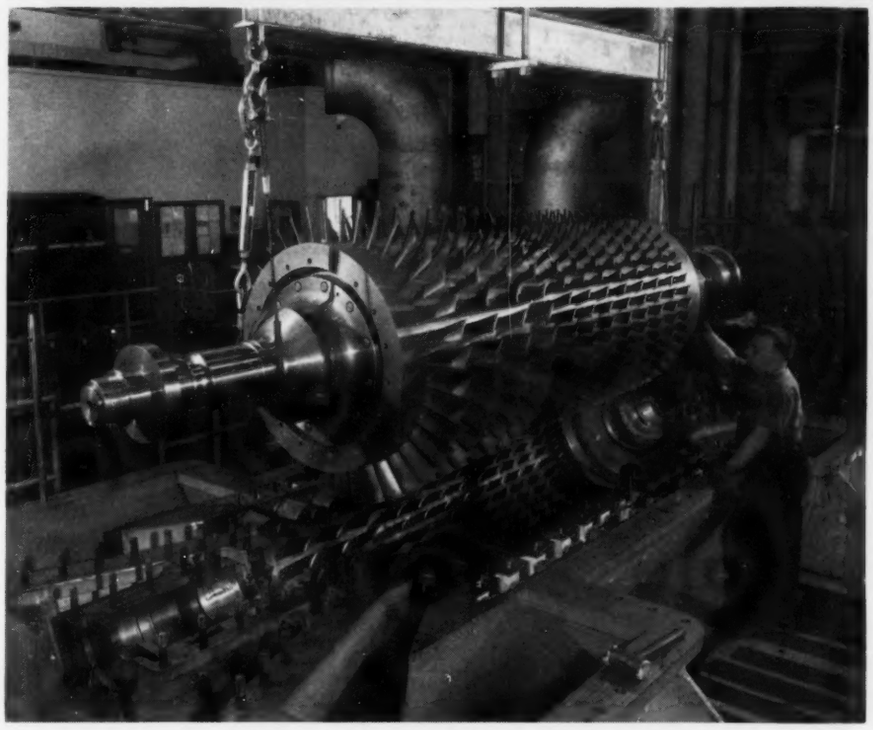


The track is fabricated in a large number of standard sizes ranging from 8 to 20 in. deep. Special sizes and greater depth tracks can be made for unusual applications when required. The track rail dimensions match with existing Cleveland Tramrail track dimensions, permitting extension of all systems now in service.

The track fills a need where distances between track supports are great. For most situations with such limitations, the new track reduces or eliminates the need of an especially engineered structural framework so often required for supporting overhead tracks. As an example, when "Tarca Track" is used for crane bridges, single-girder three-ton cranes or double-girder five-ton cranes can be made for operation on runways with tracks spaced up to 100-ft centers. This dwarfs old maximum standards and offers a new frontier for the economical solution of handling problems that previously were difficult or very costly.

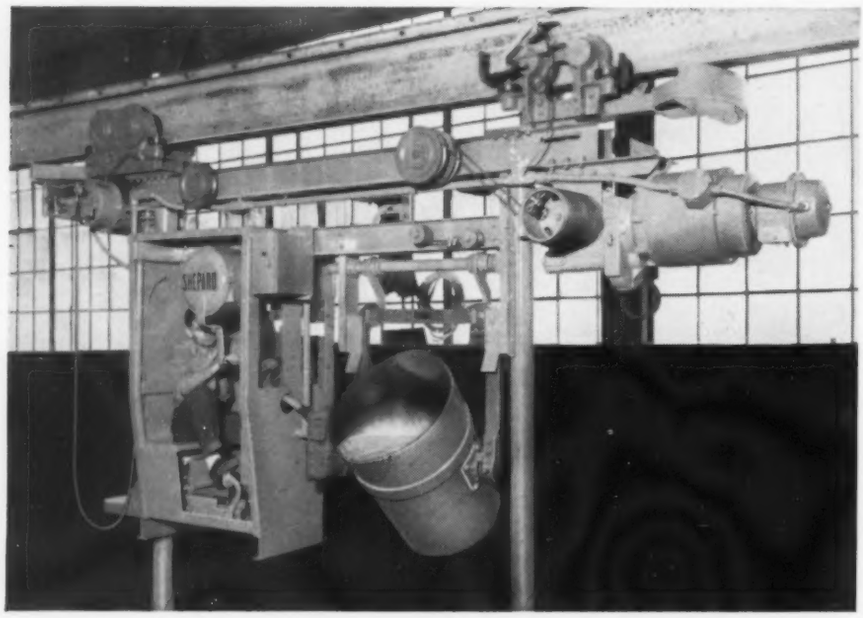
A problem that has troubled users, and erectors of overhead track systems in particular, has been the variance in track depth. This has necessitated a great amount of abnormal cutting, shimming and fitting to aline and level the tracks. Often the top flange, or lower track flange, or both, are out of square. This complicates erection work and if not corrected or compensated for, may cause wheels to not bear squarely on the track. In conse-

TESTING BLAST FURNACE AXIAL COMPRESSOR



This first axial compressor with full adjustable stator blade control ever used for blast furnace blowing is shown being assembled for testing in Allis-Chalmers Manufacturing Co.'s shops prior to shipment to a plant of U. S. Steel Corp. This is the largest axial flow compressor ever built for blast furnace service. Its full adjustable stator blade control permits operation over a very wide volume range and the unit is designed to provide large volumes of air at very high efficiencies.

JOB-MATED



for Hot Metal Handling

Shepard Niles Hot Metal Carrier

It only takes **one man** to move and pour hot metal — swiftly and safely — with a Shepard Niles Hot Metal Carrier. And because each carrier is **JOB-MATED** — built with the components best suited to meet **your** exact on-the-job conditions — it will last longer, require minimum maintenance and practically no downtime. Care like this in our plant means significantly lower cost operation in yours.

For full details on this labor-saving method of low-cost handling, write for latest bulletin. Ask to have a Shepard Niles representative call.

America's Most Complete Line of Cranes and Hoists

Member of Hoist Manufacturers Association, Inc.

SHEPARD NILES
CRANE AND HOIST CORPORATION

1273 Schuyler Ave., Montour Falls, N.Y.

quence, operation of traveling units will be troublesome, wear rapidly and maintenance will be extensive.

"Tarca Tracks" are uniformly straight and true with all dimensions accurately held. They are not subject to usual mill-beam tolerances and distortions, because such beams are not used in whole or in part for their construction. Therefore, erection is faster and greatly simplified. A better, high-quality system is the result.

Deflection of the tracks, even under full load is very small. Standard deflection will not exceed 1/450th of the span. For applications with spans of approximately 50 to 60 ft between supports, a ratio of 1/600th is normally used. For longer spans, a proportionally higher ratio is used. This does away with "hills and valleys" in the tracks and greatly eases the load propulsion effort required.

The method of supporting the tracks, using an all new ball and socket swivel connection both at the ceiling or superstructure and again on the top flange of the track, provides complete flexibility. The flexible suspension helps equalize wheel loads, eliminates bending stresses in the suspension fittings, and of major significance, promotes free rolling of all wheels.

The tracks can be used for either hand-power or electrified installations and may be connected to track switches. Systems can be developed for nearly every handling situation requiring straight or curved tracks for all loads up to 20 tons. Standard tracks are available in lengths to 60 ft.

RAMMING MIXES

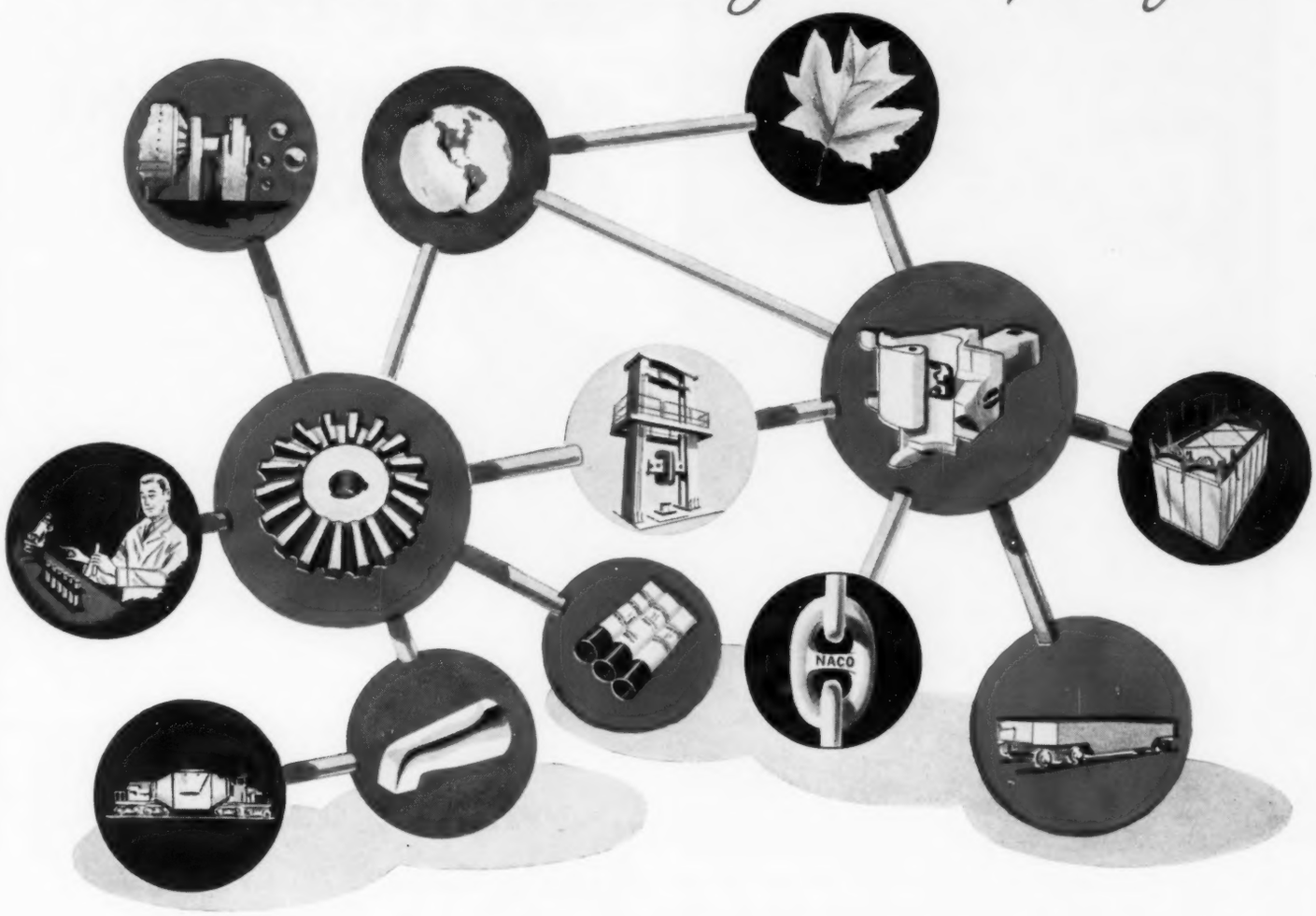
△ The availability of two new, high-alumina ramming mixes, known as Hi-Ram 70 (70 per cent alumina) and Hi-Ram 90 (90 per cent alumina) has been announced by Kaiser Refractories & Chemicals Division, Kaiser Aluminum & Chemical Corp.

Both products contain the minimum amount of water to give an excellent ramming workability and are shipped in 200-lb steel drums which provide additional storage life.

Typical uses for Hi-Ram 70 include burner blocks, burner tunnels and firing cones, forge furnace

We changed our name to

National Castings Company



We recently changed our name — from National Malleable and Steel Castings Company to National Castings Company — for these major reasons:

Broadened Marketing Base through a coordinated program of new-product research and development.

Acquisition of Properties as part of a general diversification plan.

Increased Scope and Depth of services on both a national and international scale.

We feel, too, that our new, briefer name — National Castings Company — will be more readily remembered. It will probably profit you to remember National Castings Company if your business can use any of these National products or services.

A-6216A

Capitol Foundry Division, Phoenix, Arizona . . . Job lot and production castings for Western mining, ore processing and metalworking industries.

Grand Rapids Die Casting Company, Subsidiary, Grand Rapids, Michigan . . . Non-ferrous die castings for appliance, automotive, and other high-volume production industries.

Grand Rapids Plating Company, Subsidiary, Grand Rapids, Michigan . . . Quality plating and finishes for durable consumer goods producers.

Hill Hubbell Company, Subsidiary, Cleveland, Ohio . . . Corrosion resistant pipe covering for fluid distribution systems and pipelines.

Industrial Division, Cleveland, Ohio . . . Castings for automotive, farm, road construction equipment, appliance, electrical transmission, hardware and other industries.

International Division, Cleveland, Ohio . . . Direct sales of domestic production; licensing of National products overseas.

Metallurgical Research Laboratory, Cleveland, Ohio . . . Practical research for improved metals and methods.

National Castings Company of Canada, Ltd., Toronto, Ontario . . . Sales of National transportation products in Canada.

Technical Center, Cleveland, Ohio . . . Engineering, research, development of National products; contract testing and development.

Transportation Products Division, Cleveland, Ohio . . . Railway, marine, trucking, barge, mine and mill industries; Speedloader container handling systems.

NATIONAL CASTINGS COMPANY
Cleveland 6, Ohio

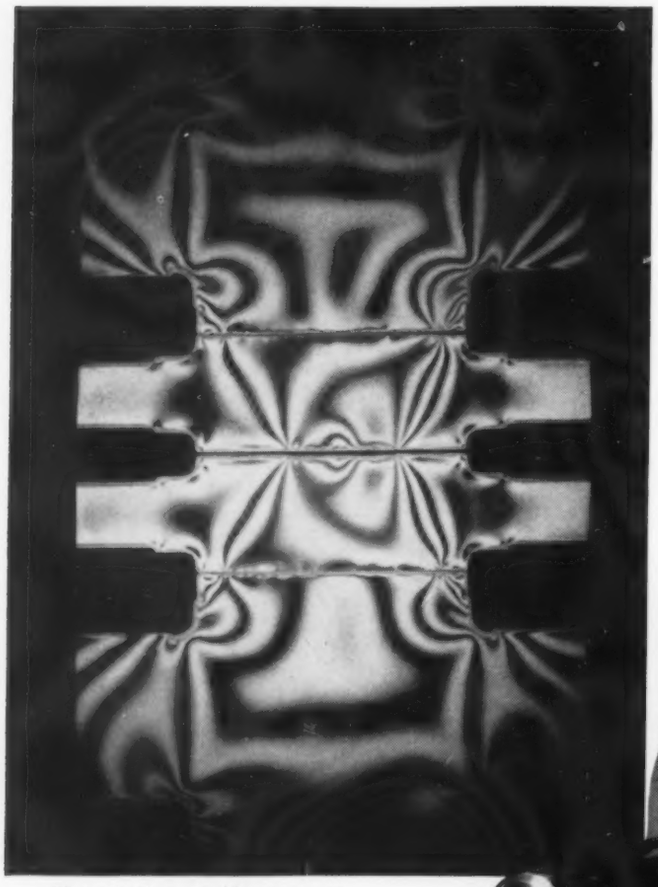


Photo-elastic study of four-high mill showing pressure patterns on roll surfaces.

MIDVAC ROLLS

MADE TO STAND MAXIMUM STRESSES AT ALL POINTS

. . . and produce fine *Micro Lustre*® finishes

Extensive photo-elastic studies of roll pressures by Midvac engineers reveal a build-up of pressure patterns in certain areas. For long life, rolls must be able to stand these extreme pressures at all points.

That is why Midvac Rolls outlast others. They are specially made to stand maximum pressures wherever they build-up. The Midvac process of consumable electrode melting eliminates atmospheric and refractory contamination, therefore inclusions are held to a minimum assuring the strongest rolls possible. Of the hundreds of Midvac Rolls now in service not one has ever broken and their deep Micro-Lustre grain structure has permitted operators to repolish them in ½ the time of other rolls.

Midvac Rolls are precision ground to a deep, black, Micro-Lustre finish . . . assuring rolling of stainless steel, foil and precious metals free of surface imperfections.

Improve product quality and get more footage out of every roll—specify Midvac Rolls on your mills. Midvale-Heppenstall also makes forged rolls for rolling steel and nonferrous metals, paper, plastics and rubber.

MIDVALE-HEPPENSTALL COMPANY • **NICETOWN, PHILADELPHIA, PA.**
SUBSIDIARY OF HEPPENSTALL COMPANY, PITTSBURGH, PA.

H MH *Midvac Rolls*

VACUUM AND CONSUMABLE ELECTRODE STEELS • BACK-UP ROLL SLEEVES • FORGED STEEL ROLLS • FORGINGS
RINGS • PRESSURE VESSELS • INDUSTRIAL KNIVES • DIE BLOCKS • MATERIALS HANDLING EQUIPMENT

repairs, crucible furnace linings, reverberatory furnaces, ladles for gray and malleable iron.

Hi-Ram 90 is especially suited for use in furnaces which are operated under high temperatures. The product is particularly resistant to erosion and abrasion and has been designed for use in rotary hearth furnaces, forge heating furnaces and reheat furnaces. It may also be used in crucible covers, ladles and soaking pits.

WELDING UNIT

△ The new Stoody Automatic Welding Systems Model MR is a multi-spindle rebuilding unit and is the only roller-idler machine with offset main spindle support arm providing minimum head adjustment from tread to flange.

Other operating features include a columnized, easy-to-operate electronic control panel; full welding heads; wire straighteners; maintenance-free flux valves and shutoff mechanisms; and a rugged carriage assembly that is engaged for directional travel by a simple three-position level.

This unit can be used with layer wound coils or economical 500-lb Payoffpaks. System includes two 500 amp constant voltage, 100 per cent duty cycle power sources.

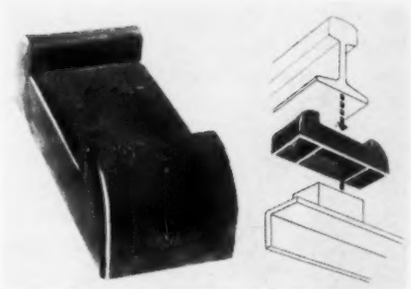
RAIL INSULATORS

△ The Glastic Corp.'s new insulating supports for exposed third rails of overhead cranes and other heavy-duty conductor-rail handling equipment combine high impact strength, long-lasting insulating properties and ease of installation.

The rail insulators are molded of fiberglas reinforced polyester. They therefore withstand the severe, continuous shock loads inherent in crane operation. They resist carbon tracking that is caused by arcing from the third rail. They also bear up under strain caused by thermal expansion and contraction of long continuous rail installations.

Cored construction of the insulators not only saves material and reduces weight, but also makes them easier to install than bolt-on type insulating supports.

Fiberglas reinforced plastic offers advantages over other types of materials sometimes used. These insulators have six to eight times greater impact strength than porcelain insulators. Unlike wooden supports, they are resistant to carbon tracking and charring.



Crane rail insulator is simply slipped over steel block welded to the end of the steel strut that projects from the main girder of the crane rail system. The third rail rests in the depression in the top of the insulator.

SPACE HEATER

△ A new model with a peak output of 3,000,000 Btu per hr has been added to Dravo Corp.'s line of forced air industrial space heaters.

The Counterflo Model 300, larg-

Robinson Refractories Serve You Best!

No matter what your requirements, it pays to specify Robinson Refractories

- ★ Advanced production techniques
- ★ Modern manufacturing equipment
- ★ Rigid quality control
- ★ Field engineering service
- ★ 15 completely stocked branches
- ★ Fast, dependable delivery
- ★ Complete line for all your needs

New! Robinson Kiln Car and Floor Block. Write for Complete-Line Refractories Catalog.

THE ROBINSON CLAY PRODUCT CO. ESTABLISHED 1856 AKRON 9, OHIO

15 ROBINSON BRANCHES TO SERVE YOU BEST

AKRON, OHIO • ALBANY, N. Y. • BALTIMORE, MD. • BOSTON, MASS. • BUFFALO, N. Y. • CALDWELL, N. J. • CHICAGO, ILL. • EAST HARTFORD, CONN. • INDIANAPOLIS, IND. • NEW YORK, N. Y. (JAMAICA, L. I.) • PHILADELPHIA, PA. (POTTSTOWN, PA.) • ROCHESTER, N. Y. • SYRACUSE, N. Y. • TORONTO, ONTARIO, CANADA • YONKERS (WESTCHESTER COUNTY), N. .

R-359-136B

est heater produced by Dravo and designed for heating large open areas in factories, shops and warehouses, generates a maximum air flow of 38,000 cfpm.

The "300" is available with four types of burners—for gas, light or heavy oil, or combination gas and light oil. It may be installed upright on the floor or raised above the floor level, or it may be suspended horizontally or inverted.

Like other Counterflo models, the "300" incorporates a design in which the flame and combustion gases flow internally four times across the path of the air to be heated. Cold air, entering at the base of the heater, sweeps over two staggered banks of economizer tubes and the stainless steel combustion chamber, so that the air temperature is raised to approximately 80 F, before it is discharged through outlet nozzles. Minimum efficiency is 80 per cent, with low flue gas temperatures.

Warm air blown out through the nozzles circulates thoroughly through the area to be heated and returns through the intake vents, forming a circular flow pattern which minimizes heat loss through walls or roofs.

The Counterflo also may be operated with 100 per cent outside air, when frequent air changes are necessitated by the exhausting of fumes or smoke created during a manufacturing process.

Where a number of small offices or partitioned areas must be heated from a central source, the "300" may be operated as a duct furnace. In a large area, discharge nozzles may be rotated a full 360 deg to provide heat for all parts of the room.

CASTABLE REFRACTORY

△ A new high-strength castable refractory has been developed by The Babcock & Wilcox Co., Refractories Division, for pneumatic gun placement with low rebound loss and minimum dusting. Placed by wet or dry gun methods, the Kaogun-HS castable produces a high-strength monolithic body with outstanding abrasion resistance and excellent resistance to thermal shock.

The new castable has a recommended use temperature of 2500 F. Gunning applications for which the new castable is suitable include linings for ash pits, stacks, incinerator doors, ash hoppers, flues, boiler furnaces, dust collectors and settling chambers, and as a rear wall seal on traveling-grate furnaces.

A high-alumina cement provides an exceptionally strong hydraulic bond for Kaogun-HS which has a highly calcined, carefully graded base. Two gunning contractors on field test jobs involving three carloads of the new Kaogun-HS reported low rebound loss. The new castable has demonstrated excellent strength and dimensional stability throughout its use temperature range. Resistance to abrasion is exceptionally high.

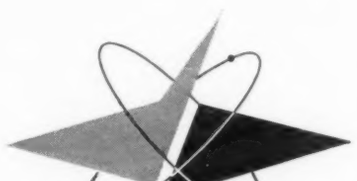
Predampening Kaogun-HS with one quart of water per bag reduces dust generation to a minimum when dry gunning. Wet gun applications require about six quarts of water per bag. After heating at 2400

New Hawk 401 Utiliscope

An Unprecedented Closed Circuit

Impressed by the potential value of closed circuit television but *depressed* by reports of high initial cost, expensive maintenance, constant requirement for difficult adjustments, and general unreliability? Then listen . . . to an unprecedented proposition from the world's oldest manufacturer of industrial closed circuit television: Indoor or outdoors, in any kind of weather with practically any degree of illumination, Diamond Electronics' all new Hawk 401 Utiliscope is *guaranteed on a money-back basis* to provide a sharp, clear picture of just about anything . . . perimeter barriers, gates, transfer points, loading docks, construction areas, vehicular movement, rooftops, hazardous areas . . . all from one safe, comfortable and convenient location. The Hawk requires no special housing, no special power supply, no special adjustments for changing light and weather conditions. Just plug it into an ordinary 110 V outlet and forget about it.

See for yourself. Call, write or wire and we'll arrange a demonstration within the week.



Diamond Electronics

Diamond Power Specialty Corporation • Lancaster, Ohio

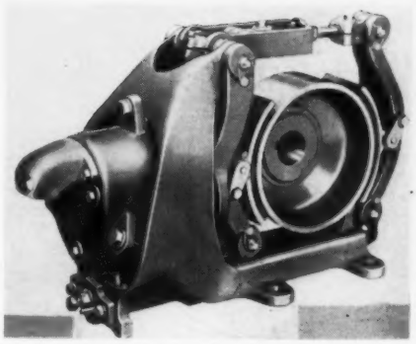
F, the Kaogun-HS has the extremely high cold crushing strength of 4200 psi.

D-C MAGNETIC BRAKE

△ Introduced by The Clark Controller Co. is a new d-c magnetic brake. This shoe-type brake is built to AISE-NEMA Standards for 600 series mill motors.

Known as the Clark Bulletin 106 B, the new brake utilizes the "nut-cracker" principle of operation. This design assures that equal pressure is applied against the wheel by both shoes, which are self-alining, symmetrical and duplicate—shoes fit either side, either end up.

Magnet coil can be changed "on the job" without dismantling the brake. This is a particularly important feature on crane applications and other installations where maintenance is difficult. Simply



remove the magnet, leave the rest alone. This provides very fast repair when necessary. Coils are epoxy-encapsulated to seal out moisture and protect coils from rough use.

The possibility of dirt interfering with the magnet operation is minimized since the magnet is hinged at the top with the widest part of the air gap at the bottom, so dirt tends to fall through.

A single adjustment compensates for lining wear and magnet gap, and is easily accessible from the top. A built-in adjustment indicator shows when adjustment is needed. Also, an indicator is provided for torque setting to simplify maintenance.

TUBE STRAIGHTENER

△ A new 5-roll rotary straightening machine, equipped with patented Syncro-Drive, has been announced by Sutton Engineering Co. for precision straightening of steel tubes at high speeds.

Known as the 18SD, the straightener has been built for ½ in. to 4-in. standard, line and extra strong steel pipe. Using a 75/100 hp, 400/1600 rpm, adjustable-speed d-c motor, throughput speeds are 175 to 700 fpm. Two additional 18SD straighteners are also being built for straightening ½ in. to 4-in. pipe at throughput speeds of 250 to 1000 fpm.

The finest possible quality of end-to-end straightness is achieved at high production speeds. Users can straighten materials previously found difficult, or even impossible to straighten, such as thin-walled tubes and bars of stainless steel, brass, zirconium, titanium and other modern metals.

The new 18SD is part of a complete line of straighteners for tubes from 1/16 in. to 6-in. OD and bars from 1/16 in. to 4-in. diam in all metals. Other straighteners are built

permits...

Proposition In Television...

for tubes up to 28-in. OD and bars up to 12 in.

In the 5-roll Syncro-Drive design, two large straightening rolls are opposed by three small pressure rolls. All 5 rolls are driven by a single motor, with the Syncro-Drive mounted between the drives for the two banks of opposed rolls. Feeding is easy and positive. Surface speeds of each bank of rolls are co-ordinated automatically, compensating for roll wear and differences in angular roll setting. Less redressing is required for maximum roll life.

The straighteners feature quick set-up and changeover, simplified roll angle adjustment with positive lock, open-frame construction for fast roll change, pneumatically counter-balanced vertical rolls, and excellent operator visibility. Power-operated screwdowns are employed on the 18SD and other large machine sizes.

In addition to 5-roll machines, these 2-roll straighteners also are available with Syncro-Drive for precision straightening or straightening and polishing metal bars.

MOTORS

△ "Life-Line" H totally-enclosed d-c motors featuring a newly-designed aluminum air-to-air heat exchanger in ratings 75 to 250 hp at 1150 rpm are offered by the Westinghouse Electric Corp. Generators in corresponding ratings are available also.

An a-c totally-enclosed vertical motor, to drive the blowers, is recessed in the d-c motor commutator bracket to reduce the over-all height of the complete unit. The

compact heat exchanger is made up of welded fin-type aluminum ducts. An internal blower pulls hot air from inside the motor through the ducts, while an external blower pulls air over the ducts and discharges heated air through the drip-proof front end of the heat exchanger, providing maximum efficiency.

A constant rate of cooling is obtained when operating at reduced speeds. The result is increased speed range available under full-load conditions as compared to an equivalent size fan-cooled motor.

Furthermore, the heights of the 75-hp and 150-hp motors, including heat exchangers, have been reduced to 32½ and 35¾ in., respectively. This compares favorably to conventional designs of similarly rated units whose heights are 44 and 52 in. This new heat exchanger

4 "EXCLUSIVES" Available only in DETRICK REFRACTORY CONSTRUCTIONS

1 Unbiased engineering directed to the single goal of materials and application best suited to the economic and operational requirements of the job.

2 A 48-year record of successful installations, highlighted by fundamental advances in refractory design.

3 The world's largest staff of heat enclosure engineers.

4 Cooperative service by competent Detrick field engineers before, during and after the installation.

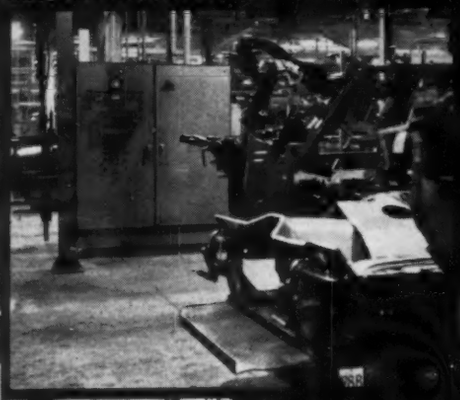
Any way you look at it, it pays to consult Detrick on any type of refractory construction — plastic, tile, castable or a combination of types.

Yours for the asking: A new and informative Bulletin on Detrick Monolithic Refractory Constructions — No. D-39.

M. H. DETRICK CO.
111 W. Washington St., Chicago 2
Offices and Representatives in Principal Cities

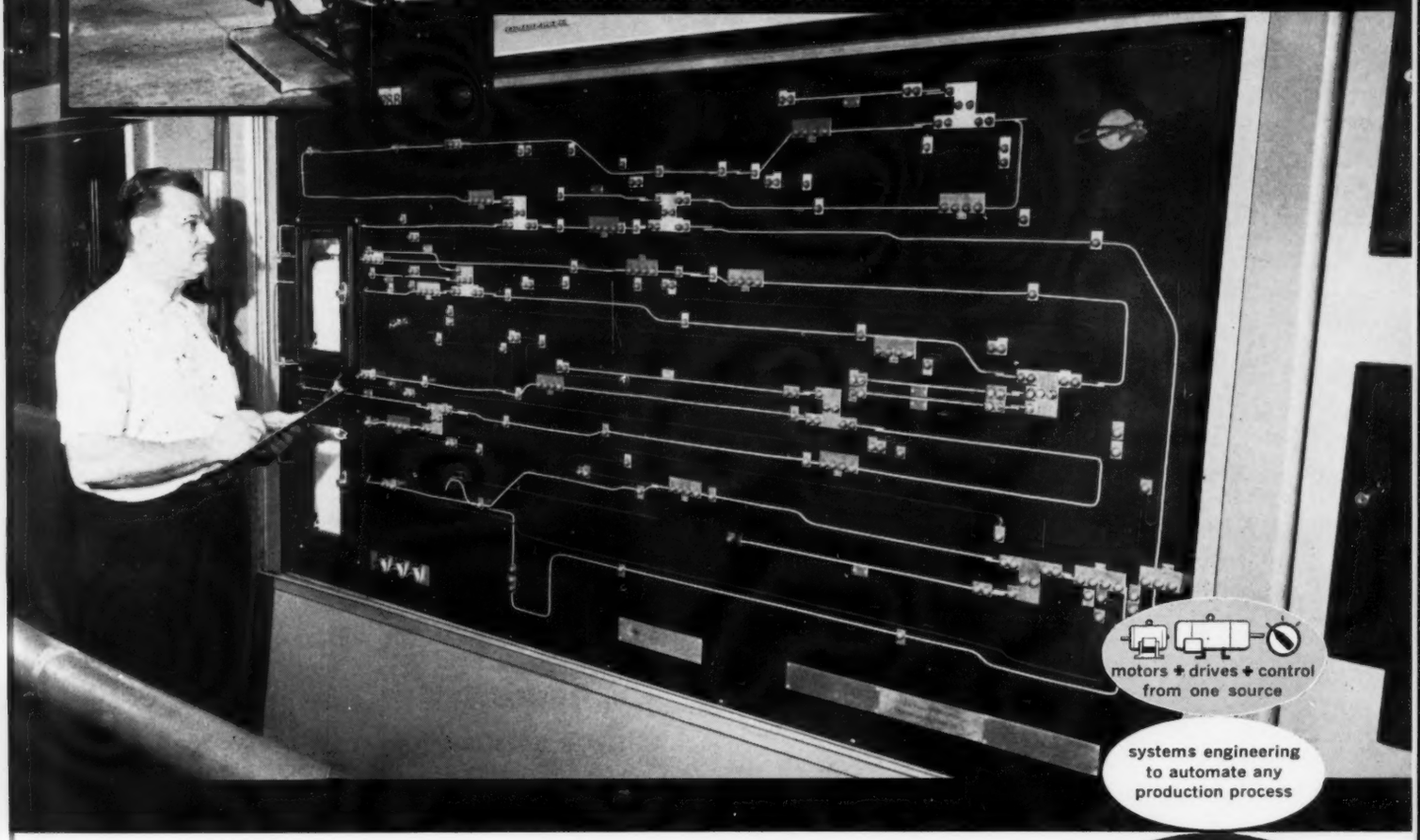
DETRICK Heat ENCLOSURES ®

FROM INITIAL BODY ASSEMBLY—Louis Allis controllers coordinate the intricate assembly of sidegate framing fixtures and underbody just prior to welding by synchronizing the arrival of three components from three different locations at precisely the same time . . .



TO PRE-FINAL ASSEMBLY AREA—where a bank of Louis Allis controllers regulate the drives powering the mating line where unitized body, stub-frame / engine assembly and running gear are assembled into units like the Plymouth convertible shown coming off the assembly line . . .

AND 3-DIMENSIONAL AREA CONTROL CENTER — which monitors conveyor operations. Any type of production interruption is quickly revealed and identified by signal light indication. Recorders provide a permanent daily record of each conveyor's operation.



LOUIS ALLIS engineered systems automate Chrysler assembly lines

An automobile assembly line is a materials handling complex of movement and synchronization. Feeder lines joining the main-line must deliver components on time — and in perfect synchronism. Still, the system must be flexible enough to accommodate speed changes when desired.

The Plymouth assembly plants in Detroit and St. Louis are models of this type of automation . . . and electrical components for the materials handling systems were custom-engineered by Louis Allis. L. A. systems engineers worked with Plymouth engineers to map the flow sequence. Louis Allis provided the adjustable speed drives and precision controls to operate the systems and supervised the installation. The result: integrated, automated systems that eliminate time loss, manpower waste, and excess materials handling costs.

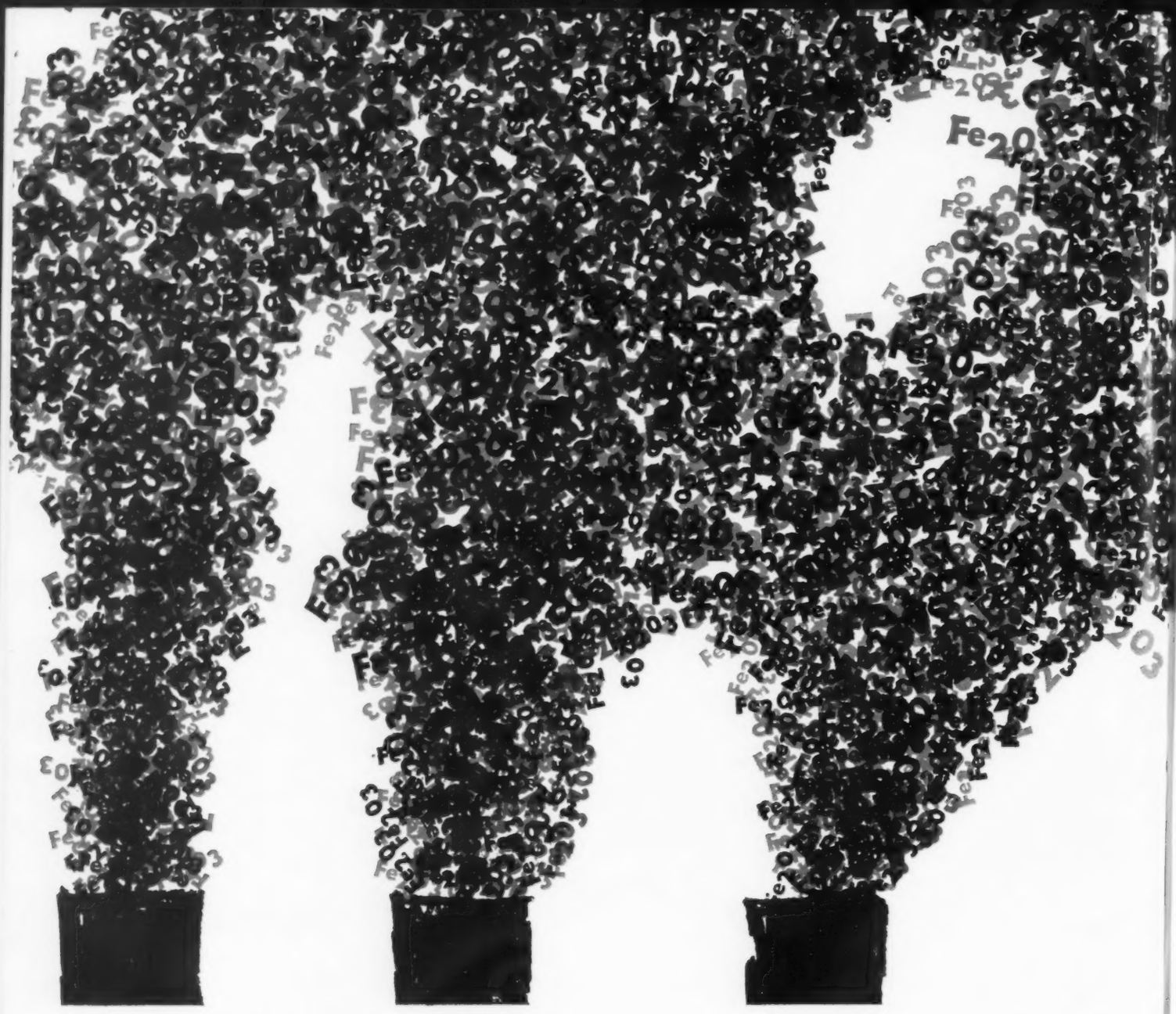
Synchronized conveyors operate at pre-set speeds by following built-in master job-rate controllers. The system provides for automatic, position-perfect transfer of body components from one conveyor to another. A three-dimensional area control center monitors and records all conveyor operations.

If your plans call for automation, contact Louis Allis for systems engineering assistance — and single-source responsibility of drive and control design, manufacturing, and service. Call the Louis Allis District Office nearest you, or write to The Louis Allis Co., 450 East Stewart Street, Milwaukee 1, Wisconsin. Ask for Bulletin 2900.

LOUIS ALLIS

ASD-239

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES



USING O_2 IN YOUR OPEN HEARTH? Chemico Venturi Scrubbers do more than simply solve the air polution problems brought on by the use of oxygen in steel making. Operating and performance figures indicate that for oxygen steel converters, oxygen lanced open hearth furnaces, electric furnaces and flame scarfing, the Chemico Venturi Scrubber solves those problems with higher efficiency and at lower cost than any other method now in operation. Specifically, these are the advantages of a Chemico Venturi Scrubbing System:

CAPITAL INVESTMENT—Chemico Venturi Scrubbers can be installed for approximately 30-50% less capital cost than required for electrostatic precipitators.

OPERATING AND MAINTENANCE COSTS—Chemico Venturi Scrubbers require so little maintenance and manpower, that over-all operating costs are dramatically lower than for other methods, even though power requirements may sometimes be slightly higher.

CONSISTENT PERFORMANCE—The Chemico Venturi Scrubber attains maximum cleaning efficiency at start-up. This peak efficiency is not decreased by subsequent changes in the gas flow or other variations in process conditions.

COLLECTION AND DISPOSAL—The Chemico Venturi Scrubber collects iron oxide dust wet and recovers it dry—free of contaminants and ready for re-use. It eliminates the common and very serious problem of how to handle and dispose of dry dust collected in an electrostatic precipitator.

WATER REQUIREMENTS—The Chemico closed cycle scrubbing process eliminates water disposal problems and cuts make-up water requirements to a minimum. Normally, no more than 50-100 GPM is needed.

PROCESS FLEXIBILITY—Adjustable Venturi throat permits automatic control of furnace draft while maintaining full cleaning efficiency.

If you are considering the installation of gas cleaning equipment, a Chemico representative would be pleased to discuss performance and cost figures with you. Chemico handles the complete job:

PLANNING—DESIGN—ENGINEERING—CONSTRUCTION and START-UP.

CHEMICO

Chemical Construction Corporation, Gas Scrubber Division, 320 Park Ave., New York 22, New York

Ferndale, Mich. Chicago, Ill. Los Angeles, Calif. Houston, Tex. Bartow, Fla. Birmingham, Ala. Pittsburgh, Pa.

motor requires less maintenance even in the dustiest atmospheres.

GENERATORS

△ A new line of packaged brushless synchronous generators, ready on delivery for connection to drivers, has been announced by General Electric Co. in the company's Custom "8000" series.

Incorporated into the standard package-unit design, according to the company's Medium A-C Motor and Generator Department, are a brushless exciter, static voltage regulator, ammeter and voltmeter, all mounted on the set.

The synchronous generators are available in 1200 and 1800 rpm ratings through 350 kw. They offer to customers the advantages of low maintenance and trouble-free design by the elimination of collector rings, brushes and commutators from the conventional exciter and generator system.

Each generator is available with either two bearings for standard coupling applications, or a single bearing with SAE adapter and flexible disk-type coupling to permit matching with diesel-engine drives.

Major modifications available in the new generators include the use of selector switches to indicate current and voltage on all three phases, cross-current compensation for paralleling of multiple units, and provision for separately-mounted meters and voltage regulators.

Hermetically-sealed silicon diodes are used as rectifiers in the generators. The rectifiers are mounted on an assembly attached to the generator shaft, and rotate with the exciter armature and main generator rotor.

Silicon rectifiers, according to the company, are as high as 99-per cent efficient, hold their efficiency with age, withstand high temperature, and have high vibration and centrifugal tolerances.

SCRAP CHOPPER

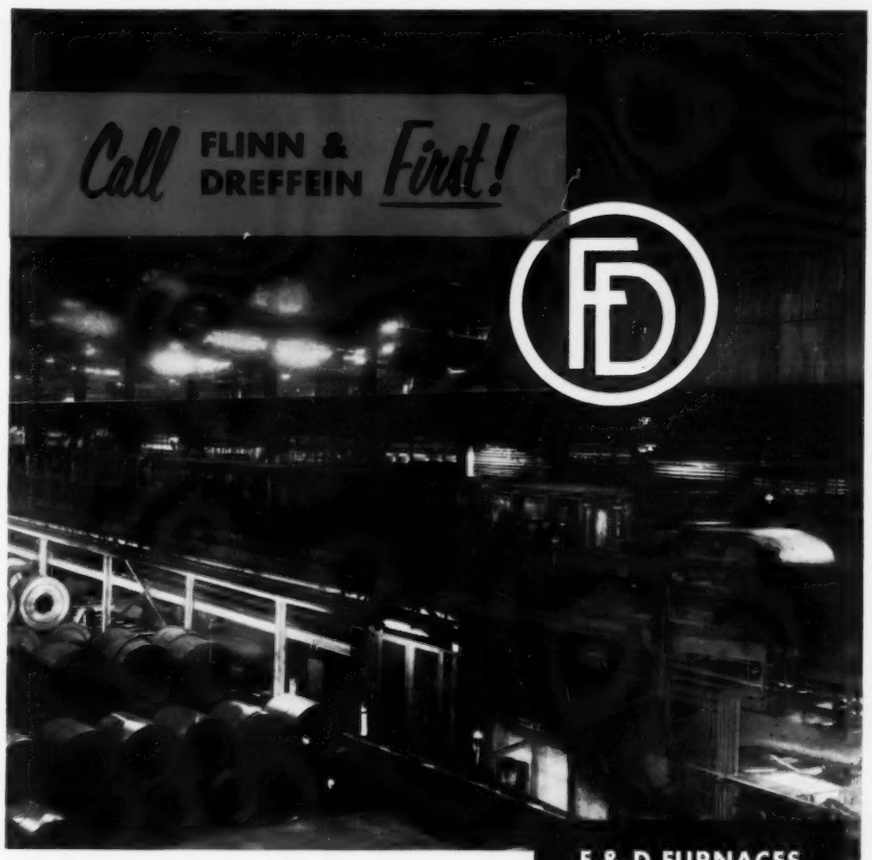
△ When slitting coiled steel strip, a small width of material is trimmed from each edge, which becomes scrap. A new scrap chopper, designed and built by Production Machinery Corp., is an improved device for efficiently cutting up this material into short lengths and discharging them into a box or conveyor for easy removal.

Scrap from the slitter is fed through adjustable steel chutes and is discharged over the fixed blade of the scrap chopper. The rugged cutter heads, quickly adjustable for varying strip widths, trim the scrap as it is fed forward. The entire scrap chopper assembly including motor drive is mounted on wheels running on a track in the floor so that it can be moved to one side of the line to permit access to the slitter for knife set-up.

Knife costs are kept to a minimum because the unit employs relatively short rotating blades, so that no long unused sections of the knives are discarded or reground. Another plus feature is a convenient wedge adjustment for knife clearance, completely eliminating any need for shims.

FANS

△ A series of ruggedly constructed fans, called "SQ" Airfoils, for varied industrial air handling applications



CONTINUOUS STRIP NORMALIZING

Pictured is part of the 330-foot long roller hearth normalizing furnace designed by F & D engineers for the Butler Works, Armco Steel Corporation.

Built for high production of various grades and widths to 52 inches of high quality, hot and cold rolled steel strip—F & D again employed latest technology and materials to establish further records of performance.

The low cost, profitable operations of F & D furnace designs are known the world over.

F & D FURNACES
...for more than half-a-century...

ANNEALING
CARBURIZING
DRAWING
FORGING
GALVANIZING
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HEAT TREATING
NORMALIZING
REHEATING
ROTARY
SLAB HEATERS

Gas and Oil Fired or Electrically Heated

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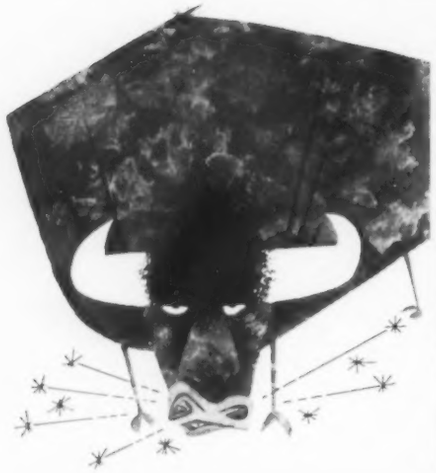

Flash Welded!

9/32" thru 2"

Taylor's Tougher

It's news! Taylor electrically flash welds ALL SIZES of TM Alloy Steel Chain! Every weld is positive, free of oxides and foreign materials. In addition, all TM Alloy Slings have patented Tayco Hooks—undergo rigid quality control, link-by-link inspection and scientific testing. These factors plus a signed Test Certificate assure maximum, trouble-free service and lower costs! Call your distributor or write direct for Bulletin 14-A today.

Chain is our specialty — not our sideline!

Taylor Made CHAIN SINCE 1873

S. G. TAYLOR CHAIN CO., Inc.
General Office: Hammond, Indiana
Plants: Hammond, Ind., and Pittsburgh, Pa.

has been introduced by Chicago Blower Corp.

New aerodynamic design of wheel and housing inlet enables fan to operate more quietly at lower speed and with greater efficiency. Because less power is required, smaller motors can be used to reduce power consumption and save installation space.

The fans, sizes 12¼ to 18¼ in. single and double inlets, carry the AMCA Certified Ratings Seal. Smaller sizes are also available. Fans have been tested and rated in accordance with Bulletin 110, Plate 1, Arrangement No. 1. Single width performance is based on Arrangement 1 fans; double width performance is based on Arrangement 3 fans.

Static pressures range from ¼ in. to 9 in. Air volume ranges up to 15,000 cfm with temperatures up to 200 F.

Steep pressure characteristics are so steep that if the original estimate of pressure required is 30 per cent low, it would change the difference in delivered volume more than 10 per cent.

Noise level is 20 to 40 per cent quieter because of the smooth lifting action of air over the entire surface of each airfoil blade. Less horsepower is used according to comparative tests made with other designs.

Housing can be positioned for discharge in any one of four ways without changing bearings. Housing is heavy gage steel with a continuous air-tight weld. Wheels are cast aluminum alloy, balanced dynamically and statically. Taperlock bushing positively locks wheel to shaft. Streamlined inlet provides smooth air flow and close wheel tolerances to reduce turbulence.

TWIN MAGNET D-C BRAKE

△ New d-c magnetic brakes (type TM) designed for heavy-duty steel mill and crane service and for applications such as hoists, conveyors, screwdowns, and ore bridges are offered by the Westinghouse Electric Corp. These brakes are available at 115, 230 and 550 volts in wheel diameters 8 through 23 in.

The brakes feature increased speed, reliability and reduced maintenance. The new design makes in-use maintenance simpler, faster and easier to perform. This is achieved through a simplified construction using six integrated assemblies.

One outstanding feature is the twin magnets which are designed mechanically independent. Either or both can be removed without releasing the brake shoes. If necessary, coil replacement is possible while the equipment is under load—for example, while a crane is in the middle of a lift. The magnet assembly can be removed and replaced, or repaired without releasing the braking action or disturbing the torque setting.

In addition, an over-the-wheel unitized tie-rod-and-spring assembly facilitates brake shoe replacement. The assembly can be removed as a unit for one-step lining replacement. Two simple adjustments, made from the top, compensate for shoe wear and spring tension. If required, the brake can also be manually released.

Interchangeable, cast-iron brake shoes are single-pivot mounted for self-alinement upon installation. Moreover, once the shoes are alined, the pivot bolts are tightened, the shoes are held in position preventing shoe tip dragging. Long wearing, molded asbestos linings are held in place with brass rivets.

The twin magnet brake meets all AISE standard dimension requirements. It will fit where any other brake of equivalent capacity must be replaced.

"Oilite" sleeve-type bearings made of low-friction porous bronze are mounted on oversize case-hardened pins for longer wear. Pivot slippage, regardless of mounting position, is prevented by a fabricated steel base which supports the pivot pins and bearings a full 360 deg.

Ductile iron brake wheel instead of annealed iron castings are a standard alternate when specified and are supplied at no extra cost.

BATTERY CHARGER

△ A fully automatic charger for batteries used in light-duty industrial trucks, personnel carriers and other small electrically-powered utility vehicles has been developed by Exide Industrial Marketing Division of The Electric Storage Battery Co.

The Exide LDR, is designed specifically as the power mate for the new Exide 3-LDT-9 battery, a heavy-duty industrial-type battery

capable of efficient performance in deep-cycling service.

It also can be used to help get best possible performance from any otherm ake or type of 12, 24 or 36-volt lead-acid battery used in light-duty applications.

The Exide LDR (light-duty rectifier) charger can keep the 3-LDT-9 battery delivering 9 to 30 per cent more electrical energy over a predicted minimum life span of four years, than most other batteries used in light-duty cycle service.

The charger does its job automatically after it is connected to battery and to a nominal 115-volt a-c source and the switch is turned on.

The charge control and other components are similar to those used in Exide chargers for heavy-duty batteries of electric industrial trucks.

The charger is fan-cooled, is fused and is equipped with ammeter and an on-off switch as part of the timer. It can be bolted to the floor or shelf, or to a wall by means of a detachable mounting bracket.

Models are available for charging 24 and 36-volt batteries in the capacity range of 200–240 amp hr and 12-volt batteries in the range of 300–360 amp hr, within 16 hr.

Silicon rectifying elements of the charger directly convert alternating current to the direct current required for battery charging. Under average conditions, they require no adjustments during normal life to compensate for aging, a serious limitation of some types. They are not affected by dust, dirt, moisture or air.

The charger begins to recharge a battery at a relatively high rate of current. Then, the current automatically is reduced at the proper time to a low finishing rate, and the timer takes over to terminate the charge.

The charger maintains the proper output from beginning to end of the charging cycle. It automatically compensates for variations in a-c input voltage.

RECTIFIERS

△ Hanson-Van Winkle-Munning Co. has announced the availability of a complete new line of automatically-controlled silicon rectifiers for high-current, low-voltage applications such as anodizing and plating, electrochemical uses and electrochemical machining.

The new line ranges in power from 1000 to 10,000 amp and 6 to 100 volts.

The main feature of the new line is a transistorized control package. The package includes a silicon controlled rectifier and provides either automatic current or voltage stabilization. This means complete, automatic control of the rectifier output for any possible application.

Depending on applications, control can be made proportional to line speed, temperature and many other production variables.

The transistorized control is, in a sense, a small electronic brain that compares the rectifier's output with the desired output programmed into it by the operator and which constantly reduces the difference between the two to zero to within ± 2 per cent or to within ± 1 per cent if desired. Should the control unit become "deranged" it can be removed and replaced in something under 120 sec by an inexperienced maintenance man.

The control also has an automatic current limiting feature which prevents the unit from being overloaded under normal overload and short circuit conditions. Under these conditions, the unit continues to operate; it will not shut down.

The current limiting feature allows the addition of future automatic voltage stabilized rectifiers on the same d-c bus without the need for additional controls.

INHERENT PROTECTORS

△ An inherent protector that may be installed in the end windings or stator slots of electric motors providing built-in protection against overheating, is now available from the General Electric Co.

The CR124H inherent protector may be applied safely in integral horsepower motors through 200 hp, 600-volt maximum, according to engineers at the company's General Purpose Control Department. Even larger motors may be protected with these devices with special design considerations. The new units may also be utilized as bearing temperature protectors in pump and motor applications.

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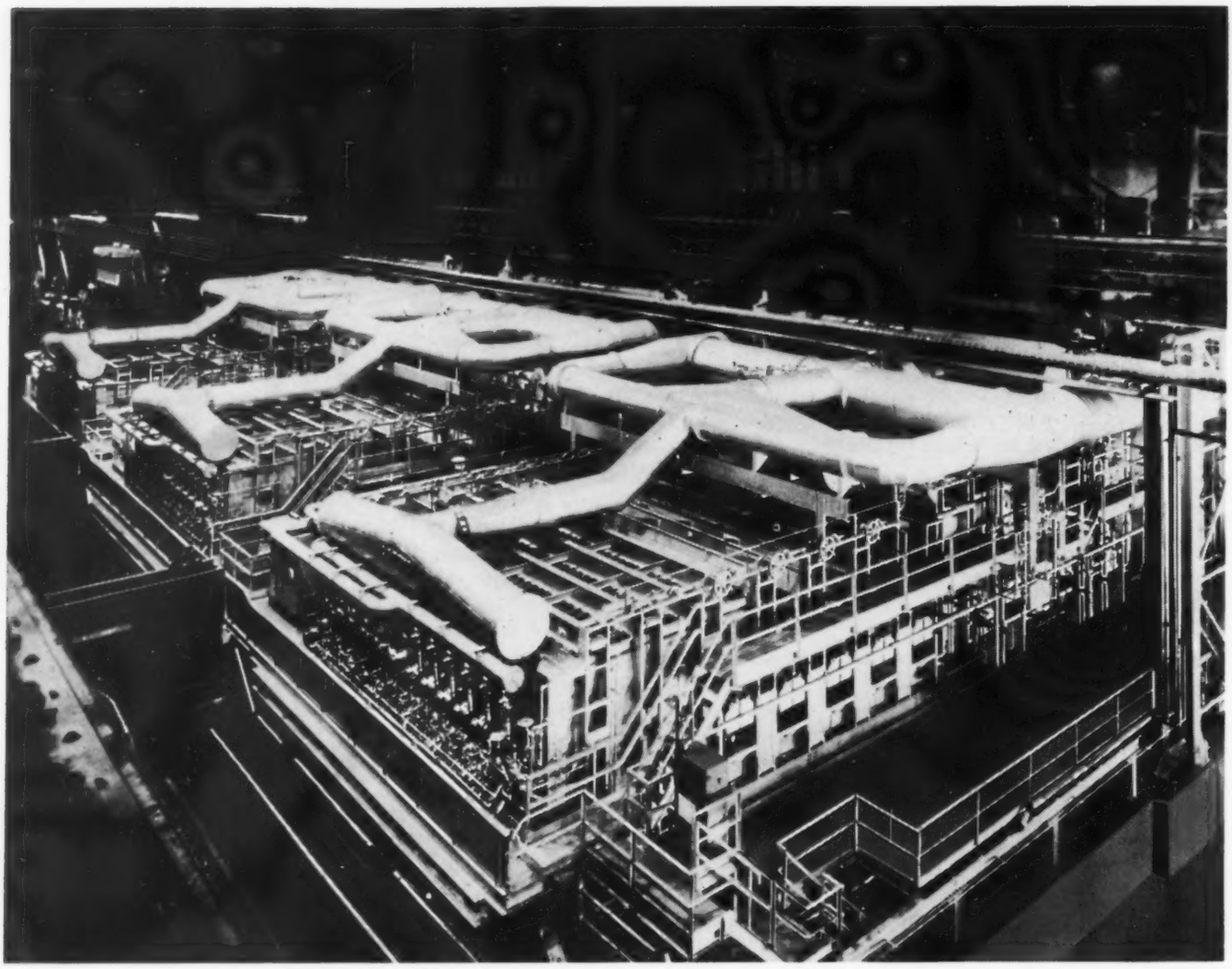

Youngstown Sheet and Tube Company gets more output, flexible control with Loftus 5-zone reheating furnaces

These three, 100-foot long Loftus continuous slab reheating furnaces serve the 79″ hot strip mill at Youngstown's Campbell works.

Heating rates and thermal gradients are closely controlled in these fully automated units. Maximum design production is 260 tons/hour. Furnace features include balanced air supply to all burners, multi-fuel automatic controls and full metallic recuperation.

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engineers said. Additional units are recommended for part-winding motors.

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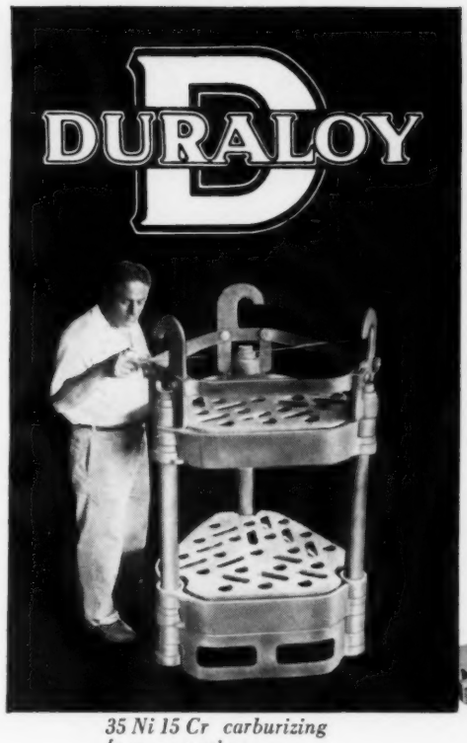
Book Review

"Magnetic Control of Industrial Motors," by Gerhart W. Heumann, "Part I: A-C Control Devices and Assemblies" and "Part II: A-C Motor Controllers" have been published recently by John Wiley & Sons, Inc., 440 Park Avenue South, New York 16, N. Y. (Part III: D-C Motor Controllers is scheduled.) Part I contains 273 pages, 6 x 9 in., is cloth bound and sells for $9. Part II contains 334 pages, 6 x 9 in., is cloth bound and sells for $9. The three volumes discuss magnetic devices and accessories used for control of industrial motors. These may be used as individual motor starters or as power actuators in automatic control systems. Primarily from an application standpoint, controllers for industrial-type a-c and d-c motors are analyzed and each type of motor is broadly discussed in conjunction with its associated controllers. Motor performance data for the a-c squirrel-cage, wound-rotor, and synchronous motors as well as data on d-c series and shunt motors are cited, accompanied by formulas useful in calculating motor performance when motors are used with different types of controllers. Also given thorough coverage are: principal circuits, selection of controller sizes and components, economic factors affecting controller selection, motor protection and existing safety codes and standards. Problems are listed at the end of some chapters. Illustrations include line drawings, tables, charts and photographs.



35 Ni 15 Cr carburizing furnace casting

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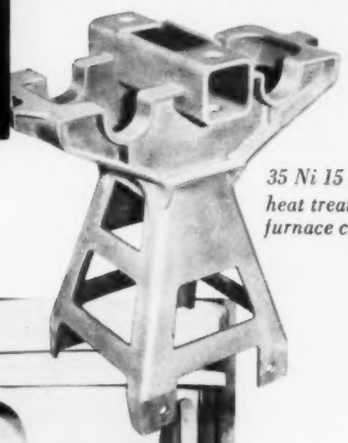

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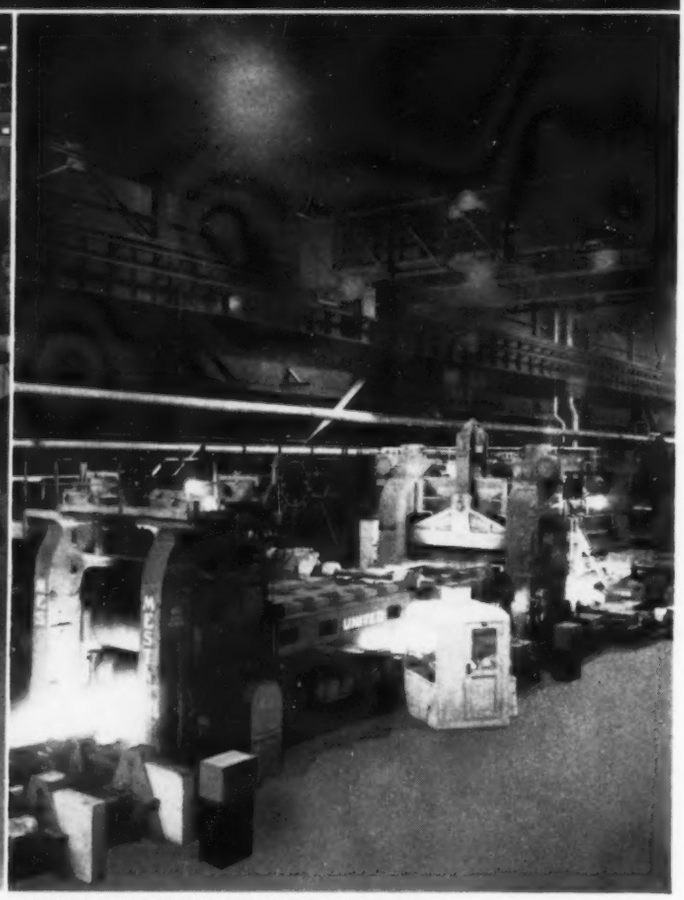

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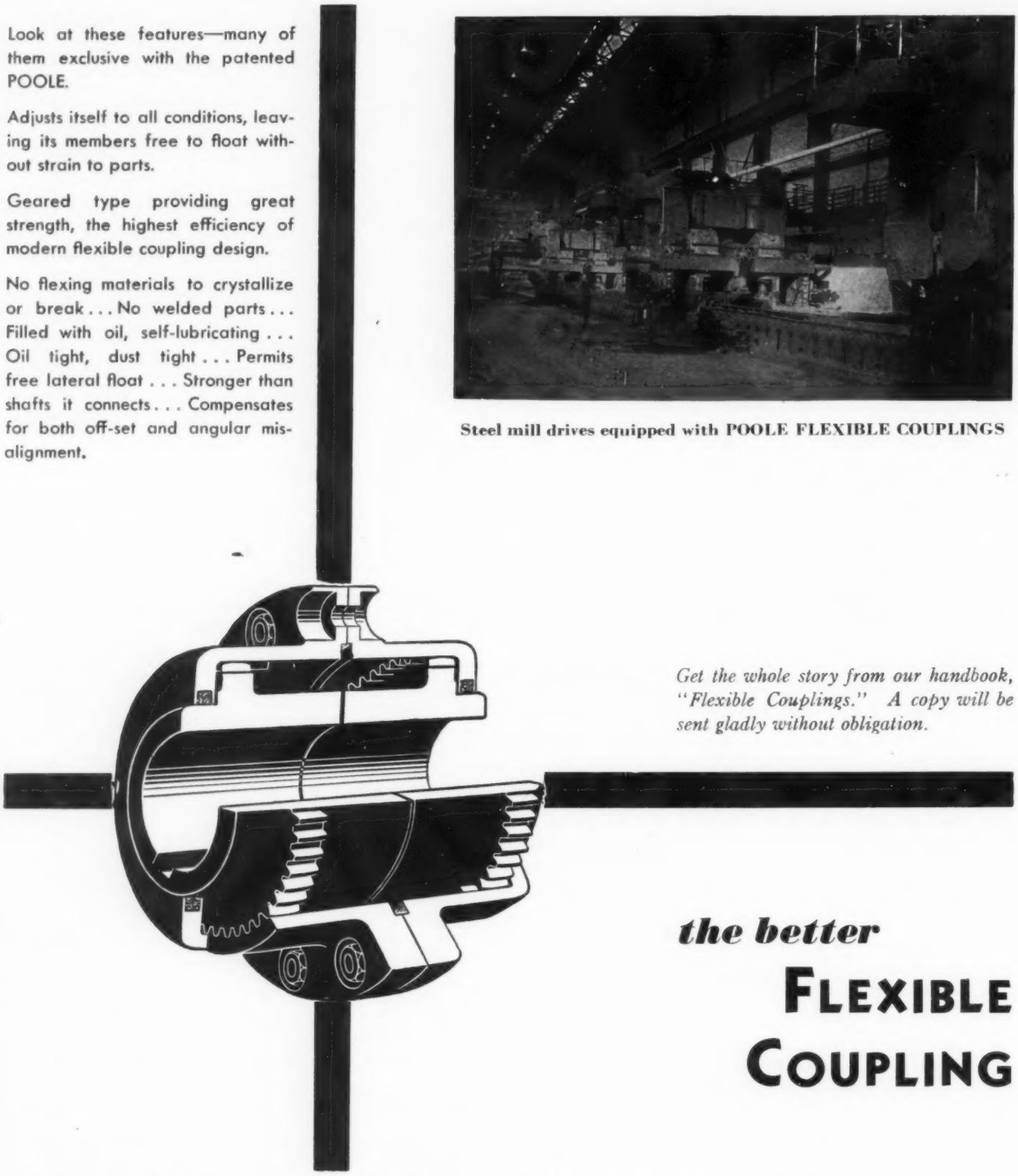

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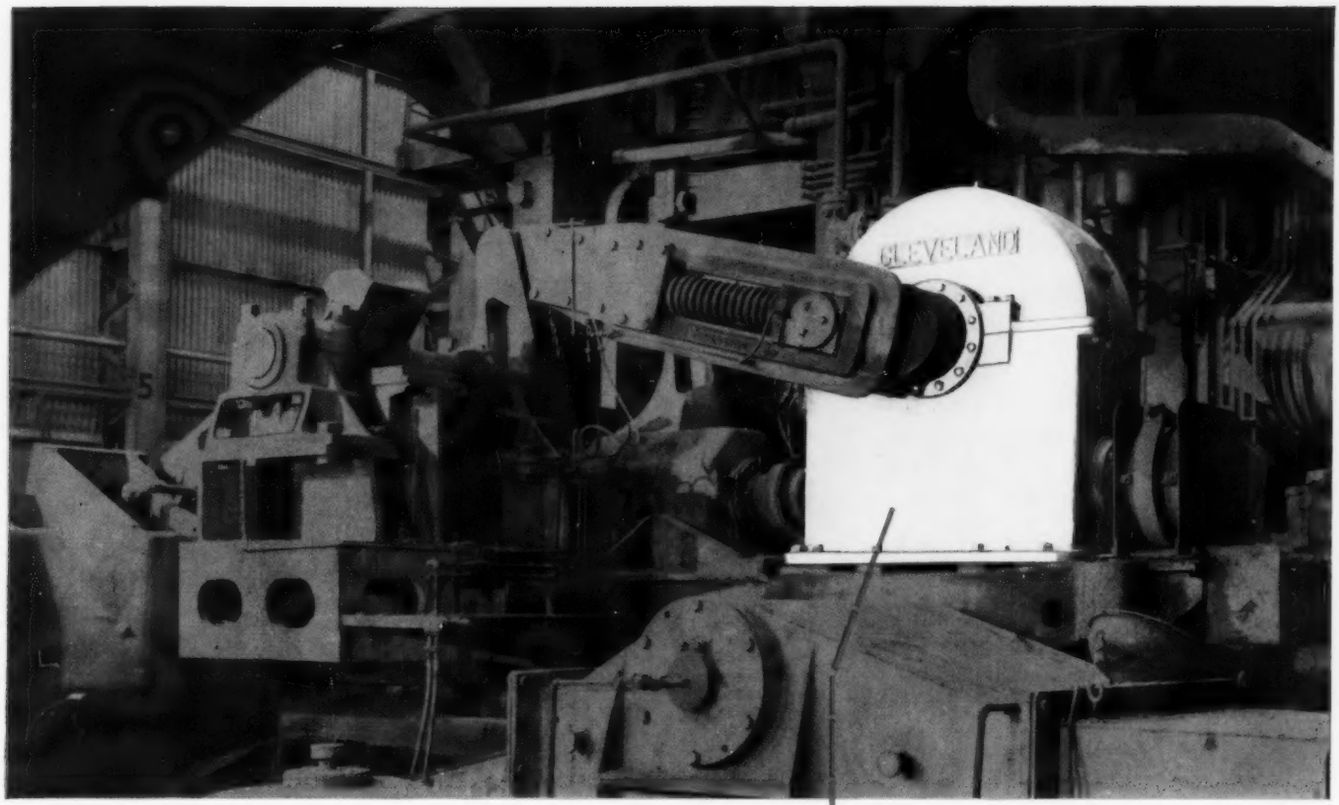

Two Cleveland Speed Reducers drive "Magic Fingers" on Kaiser Steel's New Slabbing Mill

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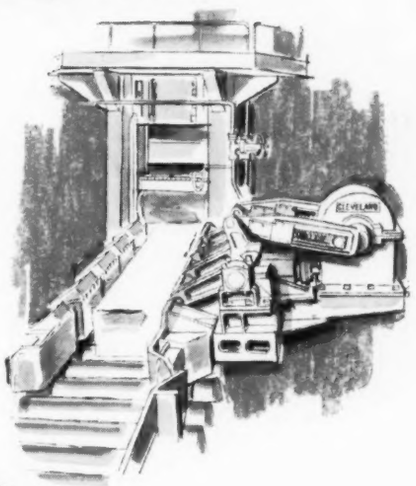

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